2

Technical Note 1-91

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM

James P. Torre Jr.
Joel T. Kalb
US Army Human Engineering Laboratory

Jeffery L. Maxey
Sander Reinhartz
Gene K. Cuccarese
Advanced Technology, Incorporated

June 1991
AMCMS Code 61110274A0011

U.S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

®Disk operating system (DOS) is a registered trademark of Microsoft Corporation.

®Quick BASIC is a registered trademark of Microsoft Corporation.

Destroy this report when no longer needed.
Do not return it to the originator.

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial products.

PAGES _____

ARE

MISSING

IN

ORIGINAL

DOCUMENT

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Note 1-91	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Human Engineering Laboratory 6b. OFFICE SYMBOL (If applicable) SLCHE	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Aberdeen Proving Ground, MD 21005-5001	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 6.11.02 / PROJECT NO. 1L161102B74A / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Marksmanship Aiming and Tracking Analysis System

12. PERSONAL AUTHOR(S)
Torre, James P. Jr.; Kalb, Joel; Maxey, Jeffery L.; Reinhartz, Sander; Cuccarese, Gene K.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM _____ TO _____	1991, June	118

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP			
12	04		M16A1 rifle	tracking	data
12	05		aim error	analysis	quantitative model
			hit probability	marksmanship	gunnery

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Scientists from the U.S. Army Project Manager for Training Devices (PM TRADE), the U.S. Army Human Engineering Laboratory (HEL), and Advanced Technology, Incorporated (ATI) worked together to design and implement a computer program to develop a data base for understanding M16A1 rifle aiming and tracking. This program was designed to run on an IBM PC-AT compatible computer. Several studies using this program examined aiming error as a function of firing position, practice, apparent target size, trigger activation, rifle noise, ballistics, muzzle deflection, target angular rate, and target engagement time. The goal of these aiming error studies was to integrate the aiming and tracking data into a quantitative model of performance.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☐ UNCLASSIFI[ED] ☐ UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	Unclassified

22. NAME OF RES[PONSI]BLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Technical Reports Office	(301) 278-4478	SLCHE-SS-TSB

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

Continuation

17. 19 10
23 02

AMCMS Code 61110274A0011

Technical Note 1-91

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM

James P. Torre Jr.
Joel T. Kalb
US Army Human Engineering Laboratory

Jeffery L. Maxey
Sander Reinhartz
Gene K. Cuccarese
Advanced Technology, Incorporated

June 1991

APPROVED: John D. Weisz
JOHN D. WEISZ
Director
Human Engineering Laboratory

Approved for public release;
distribution is unlimited.

U.S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland 21005-5001

PREFACE

The Marksmanship Aiming and Tracking Analysis System (MATAS) described in this report was developed jointly by the U.S. Army Human Engineering Laboratory (HEL), Advanced Technology, Incorporated (ATI), and the U.S. Army Project Manager for Training Devices (PM TRADE).

Mr. Jeffery L. Maxey, ATI, and Mr. James P. Torre, Jr., HEL, defined the overall system design for MATAS. In addition, Mr. Maxey provided detailed system design guidance for the parameter and graphic analysis modules. Dr. Joel Kalb, HEL, developed a preliminary version of the parameter analysis module and provided the code that formed the core for this module. Dr. Kalb and Mr. Samuel Wansack, HEL, provided valuable comments about improvements in preliminary versions of the system. Mr. Admiral S. Piper, PM TRADE, provided management and administrative support for MATAS development.

Mr. Sander Reinhartz, ATI, developed the code for system modules to include modifying and elaborating on Dr. Kalb's code for the parameter analysis module and completely developing the code for the graphic analysis module. Mr. Reinhartz also assisted in developing the guidance for using MATAS. Mr. Gene K. Cuccarese, ATI, had primary responsibility for developing the MATAS user guidance.

CONTENTS

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM

INTRODUCTION

Background

The U.S. Army Project Manager for Training Devices (PM TRADE), the U.S. Army Human Engineering Laboratory (HEL), and Advanced Technology, Incorporated (ATI) are jointly supporting the artificial intelligence direct fire weapons research test bed (TB). The TB in turn supports a research program having two main objectives. The first is to determine how to design expert systems to perform teaching roles now performed by humans. The second is to acquire through a program of experimental studies the basic knowledge needed to design cost-efficient training systems for future line-of-sight direct fire weapons.

To develop the knowledge necessary to achieve these objectives, the TB has been configured around a flexible, versatile simulation of the M16A1 rifle. This simulation is capable of manipulating training system variables associated with rifle marksmanship tasks (e.g., zeroing the rifle, self-paced slow fire, and field firing). This is the basic research tool for the TB program. It provides a well-controlled environment in which to collect data reflecting the processes underlying direct fire marksmanship and gunnery (e.g., aiming and tracking accuracy and precision).

Scientists from PM TRADE, HEL, and ATI have worked together to design and implement a series TB of aiming error studies (AES) to develop a data base for understanding M16A1 rifle aiming and tracking. These studies consist of five related experiments:

Phase I and I-B: Examine aim error as a function of firing position and practice.

Phase II: Examine aim error as a function of apparent target size, firing position, and practice.

Phase III: Examine aim error as a function of trigger activation, firing position, practice, rifle noise, and muzzle deflection.

Phase IV: Examine aim error as a function of target angular rate, firing position, and practice.

Phase V: Examine aim error as a function of target engagement time, apparent target size, target angular rate, rifle noise, and muzzle deflection.

Each successive study phase incorporates aiming and tracking skills practiced in previous phases. The same subjects participated in Phases I and II, Phases I-B and III, and Phases IV and V, though separate sets of subjects participated in each pair of experiments.

The goal of the AES series of experiments is to integrate the aiming and tracking data into a quantitative model of performance.

Data collection for all AES phases is complete. Data analysis is complete and letter reports have been published for Phases I, I-B, and II (Maxey, Torre, Cuddeback, Cuccarese, & Reinhartz, 1986; Cuddeback, Cuccarese, Maxey, Torre, & Reinhartz, 1987; Maxey, et al., 1986). Analysis is under way for the three remaining phases (i.e., Phases III, IV, and V). Final summary reports, focusing separately on aiming and tracking findings, will be published in the future.

Marksmanship Aiming and Tracking Analysis System

The Marksmanship Aiming and Tracking Analysis System (MATAS) is a software tool which allows analysts to manipulate and study the functional relationship between aiming and tracking performance and target, battlefield, and human factors parameters. The quantitative model that drives MATAS is designed to employ data generated by AES Phases I and II. This data base will be augmented as additional AES data summaries are analyzed and interpreted.

The remainder of this report consists of a user manual. It is designed to familiarize analysts with MATAS' capabilities and operation procedures. This information is structured in the following manner:

Section II: Capabilities Overview

Section III: Equipment Requirements and Installation Procedure

Section IV: System Functions

Documentation is provided in Appendices A, B, and C. Appendix A provides a flow chart of MATAS architecture, Appendix B contains a listing of MATAS code, and Appendix C provides a listing of all system files required to install and execute MATAS.

CAPABILITIES OVERVIEW

MATAS is an analytical tool designed to aid direct fire weapon designers and researchers. The primary function of MATAS is to allow the analyst to assess the impact of a variety of weapon system and battlefield factors on aiming and tracking performance. By manipulating the value of a single parameter or a set of parameters, the analyst can systematically study the effect of these changes on the probability of hitting a target.

MATAS is configured for several weapon system and target arrangements:

M16A1 Rifle - M193 and M855 projectiles. Both projectiles can engage E-silhouette, F-silhouette, or tank (front and side view) targets.

AT-4 Round - the AT-4 round can also engage E-silhouette, F-silhouette, and tank (front and side view) targets.

Target height is adjustable. Height adjustments range from 1 through 10 meters (m) for all target types. When height is adjusted, other target dimensions are adjusted proportionally.

MATAS updates system parameters dynamically. When a parameter value is changed, MATAS adjusts related parameters accordingly. For instance, if the affected target is changed from an E- to an F-silhouette, MATAS updates the target dimensions and recalculates hit probability. Also at this time, MATAS recalculates any other model parameters influenced by the parameter being changed. Through this process, the analyst can study how hit probability and the parameters affecting hit probability vary with specific parameter changes.

MATAS calculates hit probability using the single shot hit probability model described by U.S. Army Development and Readiness Command (1977). Figure 1 provides a brief summary of this model. This model assumes that the round-to-round delivery standard deviation is the same for x and y coordinates.

The probability of hittin, a target is obtained from

$$p(h) = [1/(2\pi\sigma^2)] \int_{-a}^{+a} \int_{-b}^{+b} \exp[-(x^2 + y^2)/(2\sigma^2)]\,dx\,dy$$

or, in so-called standard form,

$$= \left[(1/\sqrt{2\pi}) \int_{-a/\sigma}^{+a/\sigma} \exp(-u^2/2)\,du\right] \left[(1/\sqrt{2\pi}) \int_{-b/\sigma}^{+b/\sigma} \exp(-v^2/2)\,dv\right]$$

in which,

$p(h)$ = hit probability
a = semilength of a rectangular target
b = semiwidth of a rectangular target
x = random variable describing a delivery variation
y = random variable describing a delivery variation
σ = one directional round-to-round delivery standard deviation for the case $\sigma_x = \sigma_y = \sigma$

Figure 1. Single shot hit probability model.

MATAS is divided into two basic modules:

Parameter analysis (PA)
Graphic analysis (GA)

These modules perform similar functions but differ in their focus. Both modules allow the analyst to manipulate parameters as follows:

Projectile type
Target type and height
Aim adjustments
Crossdrift speed
Aim error
Target range (PA only)
Hit probability (PA only)
Target speed

The PA module focuses on the individual parameters that impact the outcome of the firing process. Results are summarized both tabularly and graphically for a single target and specific range. MATAS provides a hit probability estimate given user-defined target characteristics, battlefield parameters, and aim error. Additionally, the analyst can input a desired hit probability, and the PA module estimates the aim error required to achieve the probability. Once parameter values have been set, the analyst can graph the results. The PA module presents results for a specified target and range with 40%, 86%, and 99% round impact circles (see Figure 2).

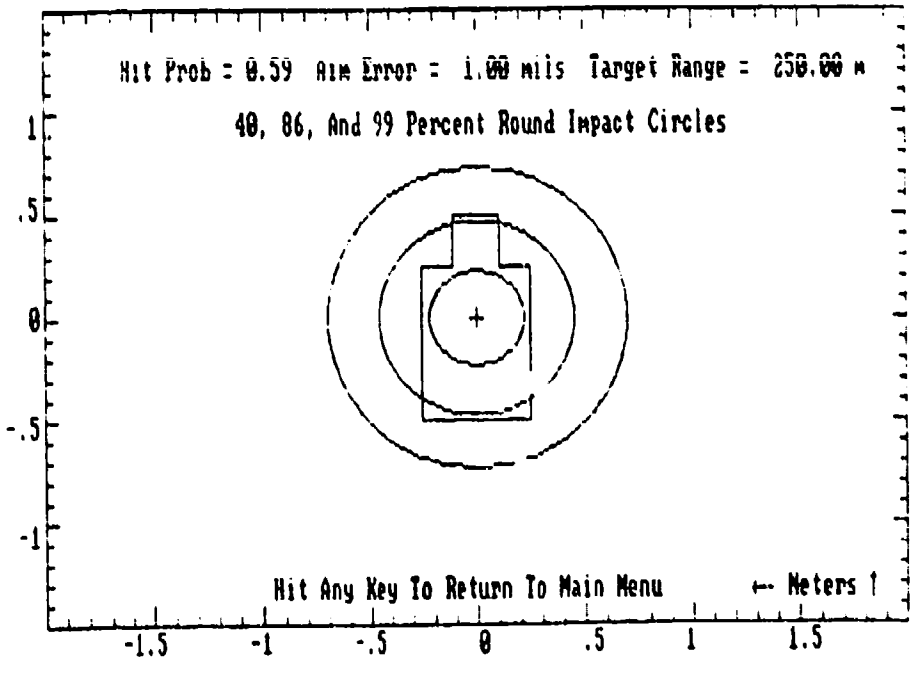


Figure 2. Parameter analysis hit probability graph.

The GA module primarily focuses on the relationship between aim error and hit probability as a function of target range. Only those parameters that are independent of target range are manipulated in the GA module. In the GA module, the analyst can graph as many as three hit probability curves reflecting different aim error values (see Figure 3). MATAS uses the parameters existing at the time the GA module is exercised to develop the theoretical curves. Additionally, the analyst can enter a set of empirical hit probability data and aim error values to produce a curve to compare to the theoretical curve(s).

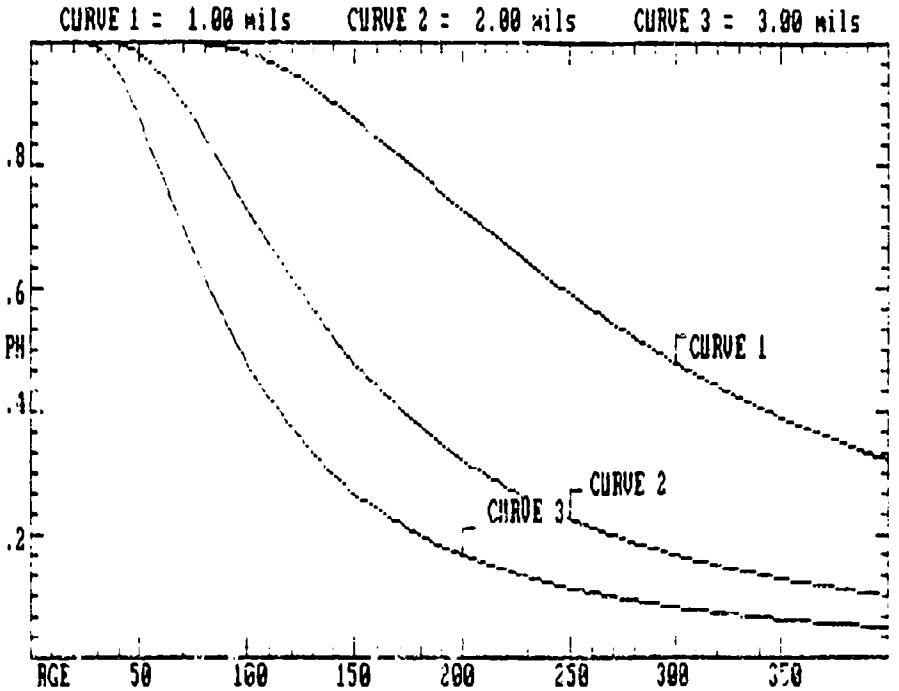


Figure 3. Hit probability for different aiming errors.

EQUIPMENT REQUIREMENTS AND INSTALLATION

The minimum equipment and system capabilities required to run MATAS include the following:

IBM-compatible personal computer (PC)
640K ram
Color monitor
Color graphics adapter (CGA) card
One 5-1/4-inch floppy drive
Version 3.1 disk operating system (DOS®)

The most desirable equipment and system configuration is as follows:

IBM-compatible PC
Color monitor
Hard disk
Extended graphics adapter (EGA) card
640K ram
Epson FX or IBM graphics printer
Math coprocessor

System Setup

MATAS is written in Quick BASIC®, Version 3.0. An IBM PC/AT computer was used to develop the system. Appendix A contains a flow chart of MATAS architecture. Appendix B contains a complete listing of MATAS code. The PC system used to develop MATAS include the following:

20-megabyte hard disk
640K ram
Math coprocessor
CGA card

It is important to establish system configuration before beginning. MATAS execution time is slower without a math coprocessor. CGA screen displays are in black and white and can be output to an Epson FX or IBM graphics printer by entering <SHIFT> <PRINT SCREEN>. EGA screen displays are in color but cannot be output to a printer.

Four versions of MATAS were developed to be compatible with most PC systems. Each stand-alone version of MATAS resides on a 5-1/4-inch floppy disk. Each disk contains DOS, MATAS, required data files, and batch commands (see Appendix C). The batch files allow the analyst to run MATAS or install the system onto a hard disk drive from which it can then be run.

Installation

Choose the diskette that corresponds to the hardware configuration of the computer system on which MATAS will reside:

CGA with math coprocessor - Disk 1
EGA with math coprocessor - Disk 2
CGA without math coprocessor - Disk 3
EGA without math coprocessor - Disk 4

Floppy Disk Drive System

To execute MATAS on a floppy drive system, load the appropriate disk in Drive A and boot the computer. A batch file (AUTOEXEC.BAT) will automatically execute MATAS.

Hard Disk Drive System

After the boot process is complete, load the appropriate disk in Drive A. To install MATAS on the hard drive, enter the command "A:INSTALL." The batch file INSTALL.BAT creates a directory called C:\MATAS into which all required MATAS files are copied. MATAS must be executed from the MATAS directory. Change the directory to C:\MATAS with the command "CD\MATAS." Once in this directory, the system can be executed by entering "MATAS."

SYSTEM FUNCTIONS

The following system functions will familiarize the analyst with MATAS capabilities. By working through the following examples, the analyst will gain an understanding of PA and GA aim error component functions. Figure 4 shows the boot-up display which controls entry into the two MATAS modules. The module menu allows the analyst to enter either module or exit the system.

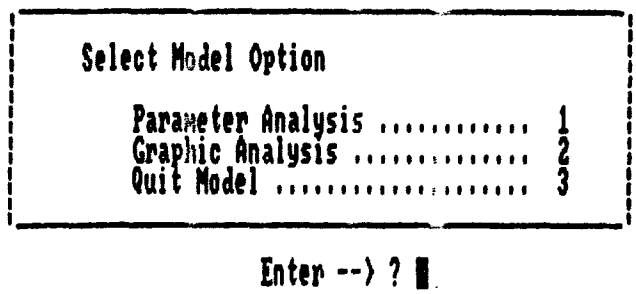


Figure 4. MATAS module menu.

Select option 1 to exercise the PA module and display the PA main menu. The display should match the display shown in Figure 5.

This menu is divided into three sections. The first section defines projectile and target characteristics; the second section defines battlefield conditions, aim error, and hit probability; and the third section lists the functions that can be used to change system parameters.

Parameter Analysis Hit Probability Estimation

When MATAS is initialized, the PA parameter values are set to the default values presented in Figure 5. Suppose the analyst had the task of estimating hit probability given the following parameter changes:

M855 projectile
+3.0 meters/sec crossdrift
150-meter target range
+2.0 meters/sec target speed
2.10 mils aim error

```
                    PARAMETER ANALYSIS
-------------------------------------------------------------------
Projectile Type       M193              Target Type   E Silhouette
Initial Pitch Angle   1.66 mils
Flight Time           0.31 s            Target
Impact Velocity     665.49 m/s          Dimensions    Heigth  1.00 m
X - Impact Point      0.00 m                          Width   0.49 m
Y - Impact Point      0.00 m                          Area    0.42 msq

Battlefield Conditions
-------------------------------------------------------------------
Battlesight         250.00 m            X - Aim Adjustment    0.00 m
Crossdrift            0.00 m/s          Y - Aim Adjustment    0.00 m
Target Range        250.00 m            Aim Error             1.00 mils
Target Speed          0.00 m/s          Hit Probability       0.59

Select Function(s)
-------------------------------------------------------------------
1 - Projectile Type/Battlesight   4 - Target Range/Speed   7 - Adjust X/Y Aim
2 - Crossdrift Speed              5 - Aim Error           8 - Graph Results
3 - Target Characteristics        6 - Hit Probability     9 - Quit
-------------------------------------------------------------------
                        Enter --> ?
```

Figure 5. Parameter analysis main menu.

Select function 1, and change projectile type to an M855 round.

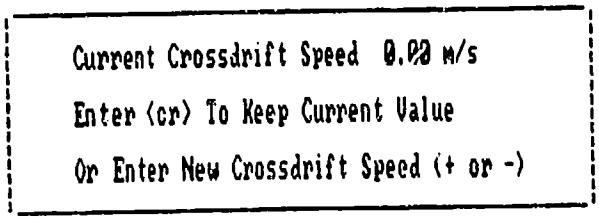
```
Current Projectile Type  M193

     M193 Projectile ..... 1
     M855 Projectile ..... 2
     AT-4 Projectile ..... 3

Enter (cr) To Keep Current Projectile Type

Or Enter New Projectile Type

Enter --> ? 2
```

On the display that follows, do not adjust the battlesight range. Enter a carriage return <cr> to bypass the battlesight range display, and return to the PA main menu.

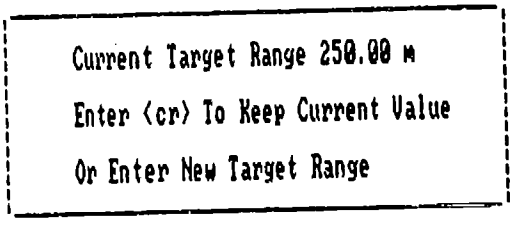
```
Current Battlesight Range  250 m

Enter (cr) To Keep Current Value

Or Enter New Battlesight Range

Enter --> ?
```

Compare the updated parameter values to those in Figure 5. The analyst can assess the impact of each change on other parameters after returning to the PA main menu.

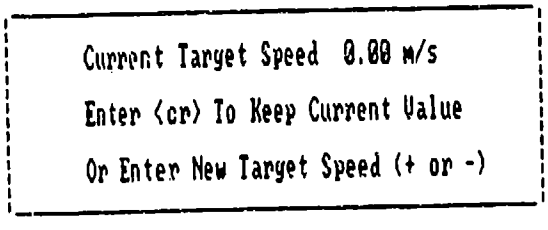
Select function 2, and input a value of +3.0 for crossdrift speed.



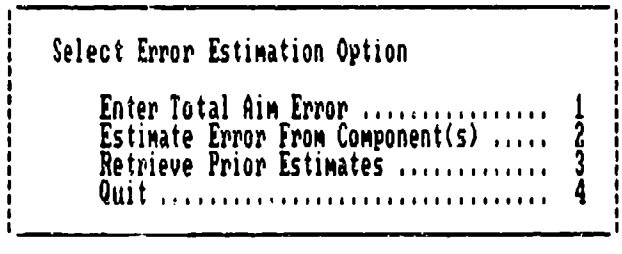
Review the PA menu. As this menu shows, a crossdrift change will affect the X dimension impact point and will reduce hit probability. Select function 4 and change target range to 150 meters.



On the display that follows, enter a target speed of +2.0 meters/sec.



Review the PA menu. Changing the target range without adjusting the battlesight range results in a Y dimension offset. Setting the target in motion adds to the X dimension offset. Together, both changes further reduce hit probability. Make the final adjustment by changing the aim error value. Select function 5, and choose option 1 from this menu.



Enter an aim error value of 2.10 mils.

```
Current Aim Error   1.00 mils
Enter <cr> To Keep Current Value
Or Enter New Aim Error

Enter --> ? 2.10
```

The following estimation summary display presents a history of hit probability estimation activity. This display includes the initial data, user-entered data, program-generated data, and the final data displayed on the PA main menu. All summary displays are structured so that inputs are presented in the middle column, while all outputs are presented in the far right column. Hit any key to return to the PA main menu.

```
                ESTIMATION SUMMARY

Estimate      Aim Error      Hit Probability

Initial         1.00             0.30
User            2.10              --
Program          --              0.28
Final           2.10             0.28

Hit Any Key To Continue
```

As expected, an increase in aim error further reduces hit probability. Examine the display to ensure that the changes made match the menu presented in Figure 6.

```
                PARAMETER ANALYSIS

Projectile Type        M855          Target Type      E Silhouette
Initial Pitch Angle    1.62 mils
Flight Time            0.18 s        Target
Impact Velocity      775.46 m/s      Dimensions   Heigth  1.00 m
X - Impact Point      -0.30 m                     Width   0.49 m
Y - Impact Point       0.11 m                     Area    0.42 msq

Battlefield Conditions
-------------------------------------------------------------------------
Battlesight          250.00 m        X - Aim Adjustment    0.00 m
Crossdrift             3.00 m/s      Y - Aim Adjustment    0.00 m
Target Range         150.00 m        Aim Error             2.10 mils
Target Speed           2.00 m/s      Hit Probability       0.28

Select Function(s)
-------------------------------------------------------------------------
1 - Projectile Type/Battlesight   4 - Target Range/Speed   7 - Adjust X/Y Aim
2 - Crossdrift Speed              5 - Aim Error            8 - Graph Results
3 - Target Characteristics        6 - Hit Probability      9 - Quit
-------------------------------------------------------------------------
                Enter --> ?
```

Figure 6. Updated parameter values.

After verifying the accuracy of parameter changes, select function 8 to graph the results (see Figure 7).

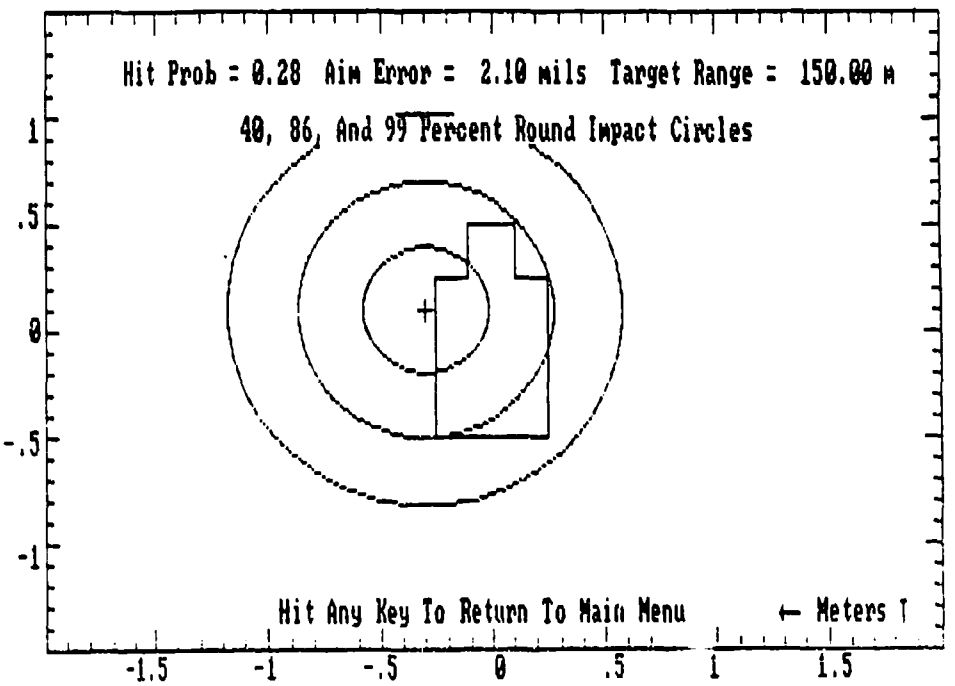


Figure 7. Hit probability graph.

MATAS generated a hit probability estimate of 0.28 based on the data just entered. The changes made in crossdrift speed and target speed resulted in an offset of -0.30 m in the X dimension impact point. Changing the target range caused an offset of +0.11 m in the Y dimension impact point. These impact point offsets caused the decrease in hit probability. Hit probability can be maximized by adjusting the aim point so that the center of the hit probability circle corresponds to the projectile target 0,0 point.

The impact point offset apparent in Figure 7 can be compensated for with an X,Y aim point adjustment. Another option is to make an aim adjustment in the X dimension and set the battlesight range to correspond to the target range to correct the Y dimension offset.

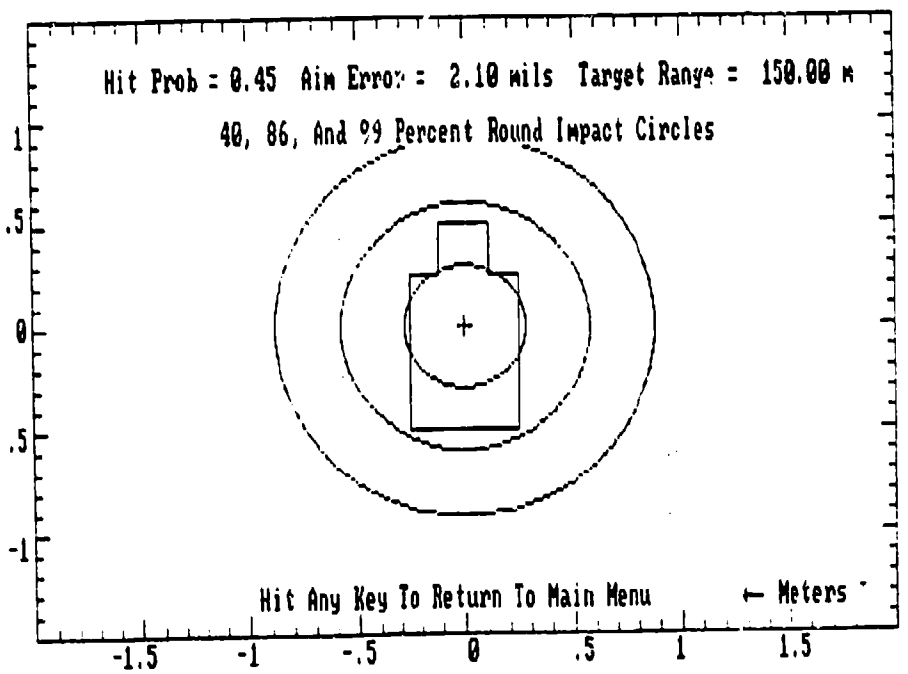
First try making the X,Y aim point adjustments. Select function 7, and enter a +0.30 m X aim adjustment to compensate for crossdrift and target speed.

```
Current Y-Aim Adjustment   0.00 m
Enter <cr> To Keep Current Value
Or Enter New Y-Aim Adjustment (+ or -)

Enter --) ? -.11
```

On the display that follows, enter a -0.11 m Y aim adjustment to compensate for the difference between the battlesight and target range.

```
Current X-Aim Adjustment   0.00 m
Enter <cr> To Keep Current Value
Or Enter New X-Aim Adjustment (+ or -)

Enter --) ? +.30
```

Examine the PA main menu. It shows that the X,Y impact point is at 0,0 which results in a greater hit probability. Select function 8 to graph the results.



Now make the offset correction by adjusting the battlesight. First, reset the Y aim adjustment back to zero. Select function 7, and enter a <cr> to bypass the X aim adjustment display. Once at the Y aim adjustment display, enter a 0.

```
Current Y-Aim Adjustment  -0.11 m
Enter (cr) To Keep Curren   lue
Or Enter New Y-Aim Adjustment (+ or -)

Enter --> ? 0
```

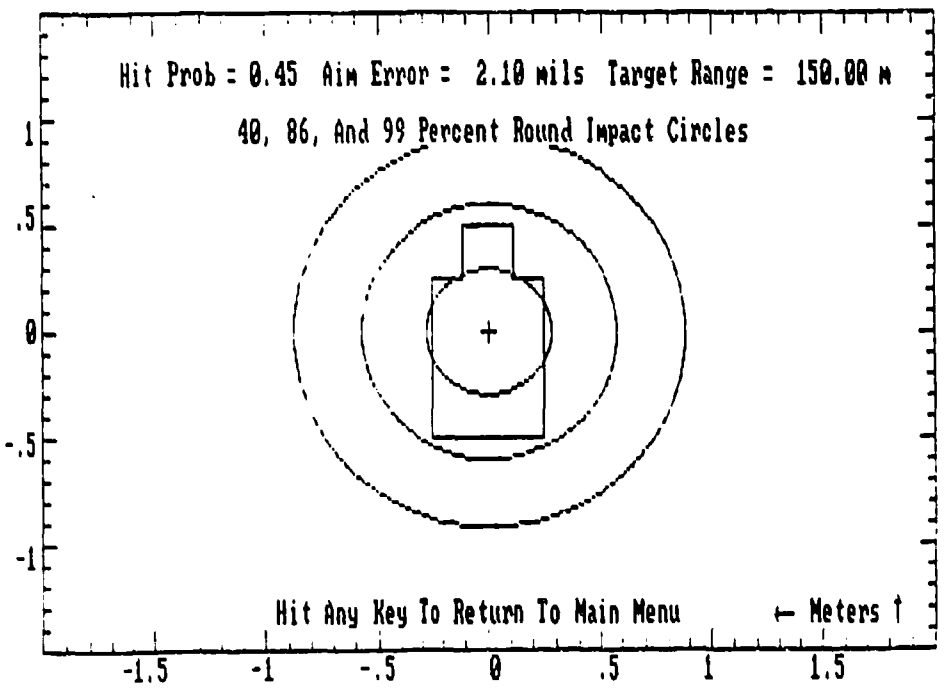
The PA main menu display shows the Y offset back to 0.11 m. Select function 1, then enter a <cr> to maintain the present projectile type. On the display that follows, change the battlesight range to 150 m.

```
Current Battlesight Range  250 m
Enter (cr) To Keep Current Value
Or Enter New Battlesight Range

Enter --> ? 150
```

The PA main menu shows that both offset correction methods result in the same hit probability estimate of 0.45.

```
                        PARAMETER ANALYSIS
-------------------------------------------------------------------------------
Projectile Type          M855              Target Type    E Silhouette
Initial Pitch Angle      0.90 mils
Flight Time              0.18 s            Target
Impact Velocity        775.46 m/s          Dimensions     Heigth  1.00 m
X - Impact Point        -0.00 m                           Width   0.49 m
Y - Impact Point         0.00 m                           Area    0.42 msq

Battlefield Conditions
-------------------------------------------------------------------------------
Battlesight            150.00 m            X - Aim Adjustment     0.30 m
Crossdrift               3.00 m/s          Y - Aim Adjustment     0.00 m
Target Range           150.00 m            Aim Error              2.10 mils
Target Speed             2.00 m/s          Hit Probability        0.45

Select Function(s)
-------------------------------------------------------------------------------
1 - Projectile Type/Battlesight   4 - Target Range/Speed   7 - Adjust X/Y Aim
2 - Crossdrift Speed              5 - Aim Error            8 - Graph Results
3 - Target Characteristics        6 - Hit Probability      9 - Quit
-------------------------------------------------------------------------------
Enter --> ? 
```

Select function 8 to graph the results.



The exercise just completed provides an example of MATAS capabilities. MATAS calculated an estimate of hit probability based on a hypothetical set of battlefield conditions. The analyst then used MATAS to maximize hit probability by making aim adjustments.

Aim Error Estimation

In the hit probability example, the analyst entered a value of 2.10 mils for aim error. This aim error value, together with the other parameters, generated a hit probability estimate of 0.45. Suppose that the analyst wants to increase hit probability to 0.90 given the battlefield situation created in previous example. What would the aim error have to be to obtain a 0.90 hit probability?

MATAS can estimate aim error based on the desired hit probability. Select function 6 and enter a 0.90 hit probability.

```
Current Hit Probability 0.45
Current Aim Error  2.10 mils
Enter (cr) To Keep Current Values
Or Enter New Hit Probability (0-1)

Enter --) ? .90
```

MATAS calculated an initial aim error estimate of 1.13 mils which the analyst can accept or reject. If the analyst wanted to change the initial estimate, a new value could be entered. However, for this example, accept the initial estimate by entering a <cr>.

```
                ESTIMATION SUMMARY
                ------------------

              Error Tolerance = .0001

  Estimate    Hit Probability    Aim Error
  --------    ---------------    ---------

  Initial          0.45             2.10
  User             0.90              --
  Program           --              1.13
  Final            0.90             0.94
```

Hit Any Key To Continue

The estimation summary display indicates that MATAS generated a final aim error estimate of 0.94 mil. The aim error estimation process is iterative, and it is based on the Newton-Raphson method for calculating the root of an equation (Pipes & Harvill, 1970). The estimation program calculates a series of aim error estimates before choosing the best value. The initial estimate of 1.13 mils represents the seed value that the system begins with. The final aim error estimate represents the value produced at the completion of the iteration process. The process continues until a solution is obtained, a failure condition is encountered, or ten iterations have been completed without obtaining a solution. (A solution exists when two successive interactions differ by less than 0.0001 in absolute value.) The initial estimate may differ from the final estimate depending on how far off the initial estimate was.

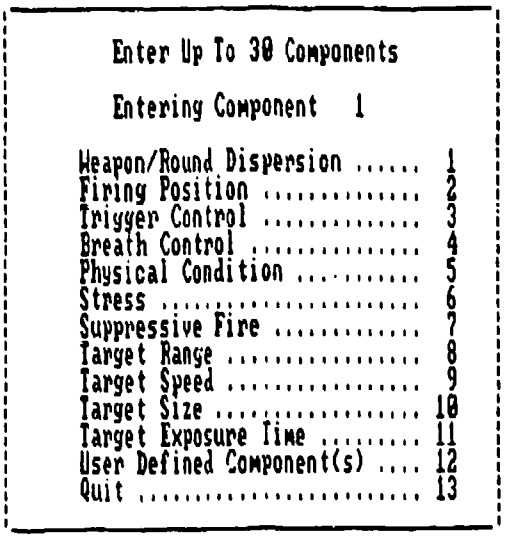
Aim Error Components

Aim error is derived from a number of components involved in the aiming and tracking process. Thus far, presentation of MATAS aim error capability has been limited to composite values. MATAS can compute aim error based on components defined by the analyst. The following example demonstrates how to calculate aim error using components of the firing process.

Select function 5 from the PA main menu. On the display that follows, select option 2 from the aim error estimation menu.

```
Select Error Estimation Option

    Enter Total Aim Error ..... 1
    Estimate Error From Component(s) ..... 2
    Retrieve Prior Estimates ..... 3
    Quit ..... 4

Enter --) ? 2
```

The component menu which follows lists 11 components of the aiming and tracking process.

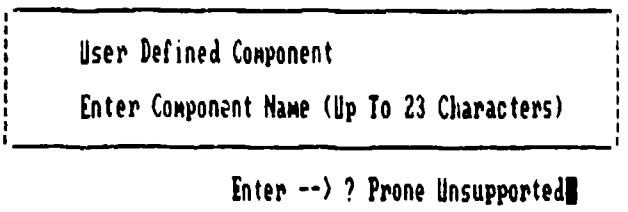


The analyst can define which components contribute to aim error and the degree of error contribution. In addition to the 11 components provided by MATAS, the analyst can define as many as 19 additional components.

Suppose the analyst wants to know the composite aim error based on the following component data:

0.43 mil prone unsupported firing position aim error
0.30 mil trigger control aim error
0.15 mil breath control aim error

Select option 12 to create a user-defined component. Enter prone unsupported to define the component name.



On the display that follows, enter 0.43 mil to define the component aim error.

```
Component Name Prone Unsupported
Enter Value (in mils)

Enter --) ? .43
```

From the component menu, select component 3 and enter an aim error value of 0.38 mil.

```
Component Name Trigger Control
Enter Value (in mils)

Enter --) ? .38
```

From the component menu, select component 4 and enter an aim error value of 0.15 mil.

```
Component Name Breath Control
Enter Value (in mils)

Enter --) ? .15
```

The composite aim error (which is the square root of the sum of the squared component values) now consists of three components with aim error values defined by the analyst. Select option 13 to quit. The display that follows presents a summary of the components previously defined and editing features.

TOTAL ESTIMATED AIM ERROR

COMPONENT NO.	COMPONENT NAME	COMPONENT VALUE
1	Prone Unsupported	0.43
2	Trigger Control	0.38
3	Breath Control	0.15
	Total Error	0.59

```
1 - Page 1      4 - Add        7 - Retrieve
2 - Page 2      5 - Delete     8 - Store
3 - Page 3      6 - Modify     9 - Quit

Enter --) ?
```

The analyst can define as many as 30 aim error components. The component summary presents components 1 through 10, followed by the second 10, and ending with the last 10. The analyst can add, delete, or modify the components using editing functions 4, 5, and 6. Previously developed component data can be retrieved, and new data can be stored using functions 7 and 8. A summary of component aim error estimation activity is presented when the analyst uses function 9 to quit.

Suppose the analyst had to change the firing position to foxhole supported with an aim error of 0.33 mil. Select editing function 6 to modify the first component. On the display that follows select component number to be modified.

TOTAL ESTIMATED AIM ERROR

COMPONENT NO.	COMPONENT NAME	COMPONENT VALUE
1	Prone Unsupported	0.43
2	Trigger Control	0.38
3	Breath Control	0.15
	Total Error	0.59

Enter Component Number To Be Modified --) ? 1

Select option 3 to modify both the name and value.

COMPONENT NO.	COMPONENT NAME	COMPONENT VALUE
1	Prone Unsupported	0.43

Enter Modification Option

Name 1
Value 2
Name & Value 3
Quit 4

Enter --) ? 3

From the component menu, select option 12 to modify the component name and aim error. Change the component name to foxhole supported

User Defined Component

Enter Component Name (Up To 23 Characters)

Enter --) ? Foxhole Supported

On the next display, enter a new aim error of 0.33 mil.

```
Component Name Foxhole Supported

Enter Value (in mils)

Enter --) ? .33
```

The component summary menu presents the updated analyst defined aim error components with the total composite aim error. Store this component set using function 8.

TOTAL ESTIMATED AIM ERROR

COMPONENT NO.	COMPONENT NAME	COMPONENT VALUE
1	Foxhole Supported	0.33
2	Trigger Control	0.38
3	Breath Control	0.15
	Total Error	0.53

```
1 - Page 1      4 - Add       7 - Retrieve
2 - Page 2      5 - Delete    8 - Store
3 - Page 3      6 - Modify    9 - Quit

Enter --) ? 8
```

Th analyst can retrieve this component set later with function 7. Select function 9 to quit aim error component development. The summary displ y that follows indicates that given the present battlefield situation, an aim error of 0.53 mil yields a 100% hit probability.

ESTIMATION SUMMARY

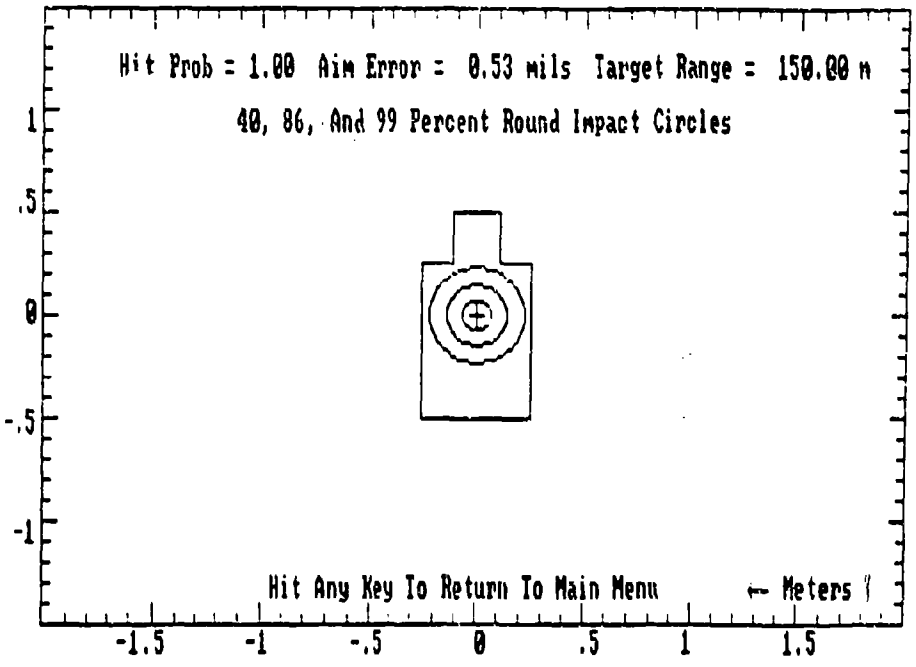
Estimate	Aim Error	Hit Probability
Initial	0.94	0.90
User	0.53	--
Program	--	1.00
Final	0.53	1.00

```
Hit Any Key To Continue
```

Hit any key to return to the PA main menu.

```
                              PARAMETER ANALYSIS
-------------------------------------------------------------------------------
Projectile Type        M855                 Target Type    E Silhouette
Initial Pitch Angle    0.90 mils
Flight Time            0.18 s               Target
Impact Velocity      775.46 m/s             Dimensions     Heigth  1.00 m
X - Impact Point      -0.00 m                               Width   0.49 m
Y - Impact Point       0.00 m                               Area    0.42 msq

Battlefield Conditions
-------------------------------------------------------------------------------
Battlesight          150.00 m               X - Aim Adjustment     0.30 m
Crossdrift             3.00 m/s             Y - Aim Adjustment     0.00 m
Target Range         150.00 m               Aim Error              0.53 mils
Target Speed           2.00 m/s             Hit Probability        1.00

Select Function(s)
-------------------------------------------------------------------------------
1 - Projectile Type/Battlesight   4 - Target Range/Speed   7 - Adjust X/Y Aim
2 - Crossdrift Speed              5 - Aim Error           8 - Graph Results
3 - Target Characteristics        6 - Hit Probability     9 - Quit
-------------------------------------------------------------------------------
                              Enter --) ? _
```

Select function 8 to graph the results.



Hit any key to return to the PA main menu. Select function 9 to quit the PA module and return to the module menu.

Graphic Analysis Hit Probability Estimation

The GA module allows the analyst to manipulate aiming and tracking parameters to generate one to three hit probability curves. The analyst sets the parameter values used to establish hit probability estimates across ranges from 1 to 400 m. In addition to developing theoretical hit probability curves, the analyst can use the GA module to plot empirical target range and hit probability data. The analyst can plot the theoretical and empirical data separately or together as shown in Figure 8.

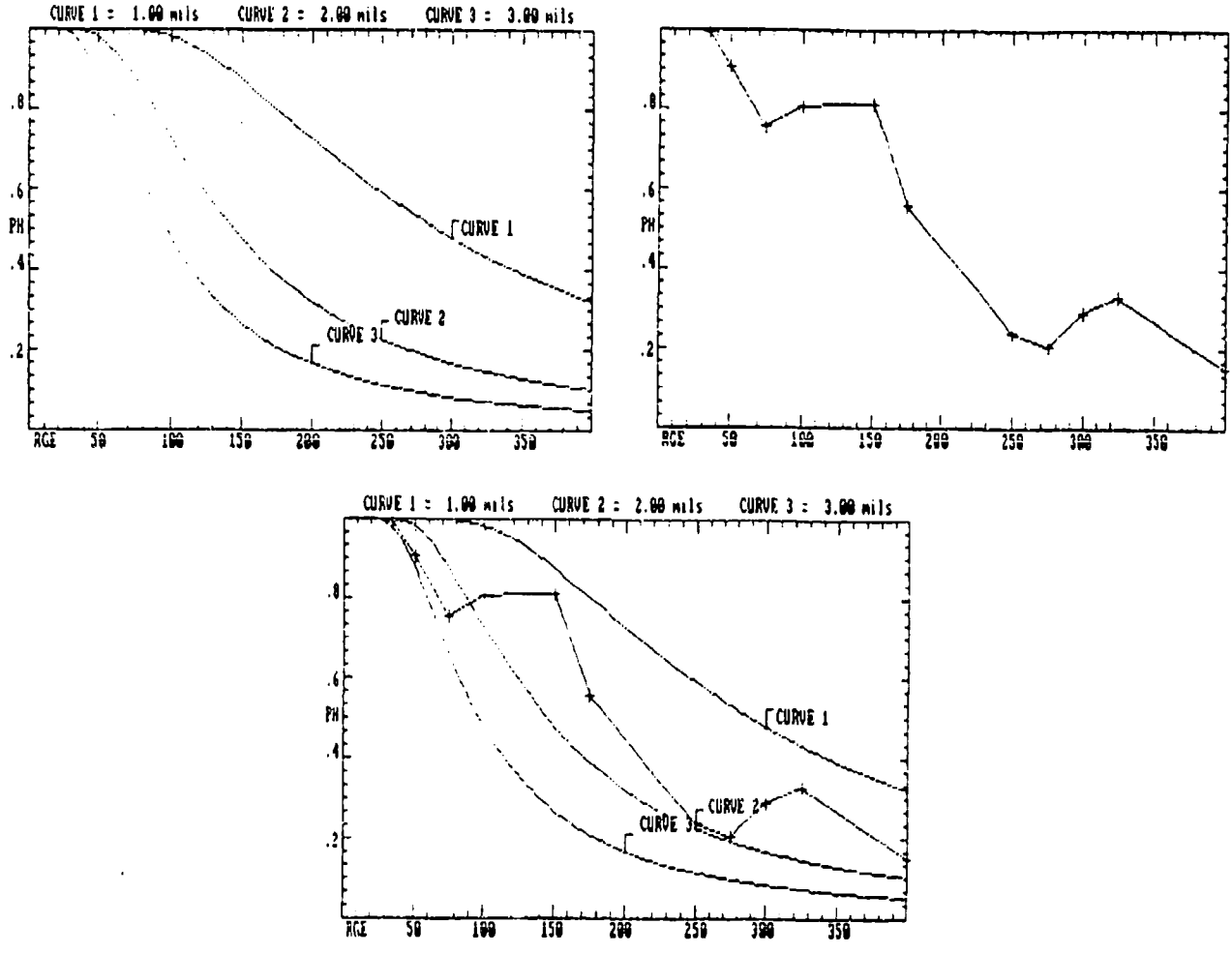


Figure 8. Theoretical and empirical data plots.

Select option 2 from the module menu, and enter the GA module.

```
Select Model Option

    Parameter Analysis ..... 1
    Graphic Analysis ....... 2
    Quit Model ............. 3

Enter --> ? 2
```

Figure 9 displays the GA main menu. This menu controls all GA module data definition and plotting functions.

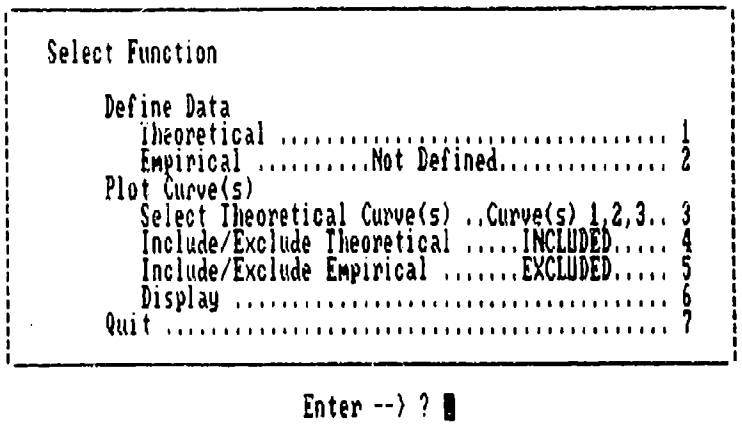


Figure 9. Graphic analysis main menu.

The analyst can define a theoretical battlefield situation through the same process used in the PA module. Select function 1 to examine the parameter menu. MATAS initializes the battlefield situation with the default parameters shown in Figure 10.

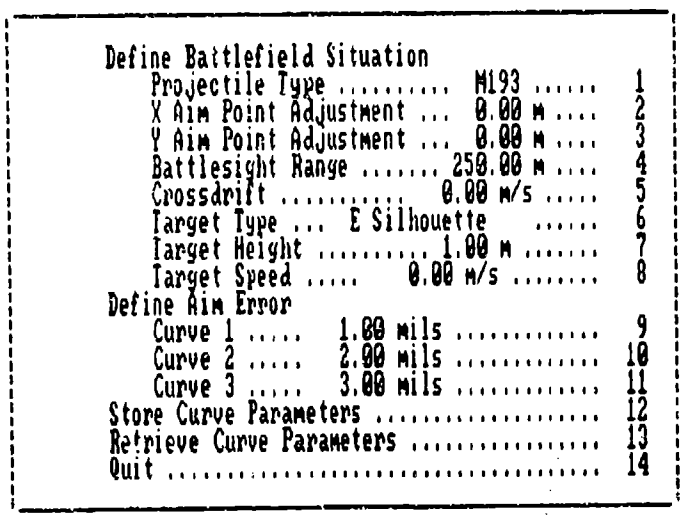


Figure 10. Graphic analysis parameter menu.

The GA module estimates hit probability across target ranges. Thus, range-dependent parameters are neither represented nor under the analyst's control. Projectile flight data and target impact data are not represented. The analyst cannot manipulate target range when developing a theoretical hit probability curve. All hit probability curves are developed for target ranges from 1 to 400 m (see theoretical data plot in Figure 8).

The GA module does not provide the analyst with the capability to develop aim error estimates from hit probability data. The analyst can use the PA module to perform this activity and enter the aim error estimates in the GA module. The analyst has the capability to estimate aim error using component values in the GA module. Select option 14 to quit, and return to the GA main menu.

Empirical data definition requires the entry of a series of target range and hit probability data. Figure 11 shows the empirical data definition menu. From this menu, the analyst can enter or retrieve empirical data. This MATAS capability allows the analyst to compare data sets to theoretical results.

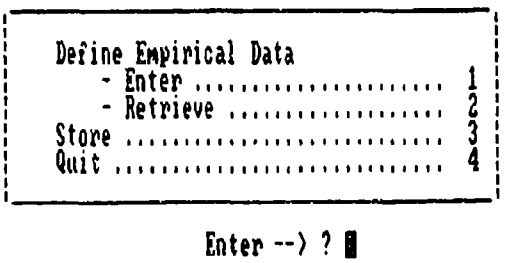
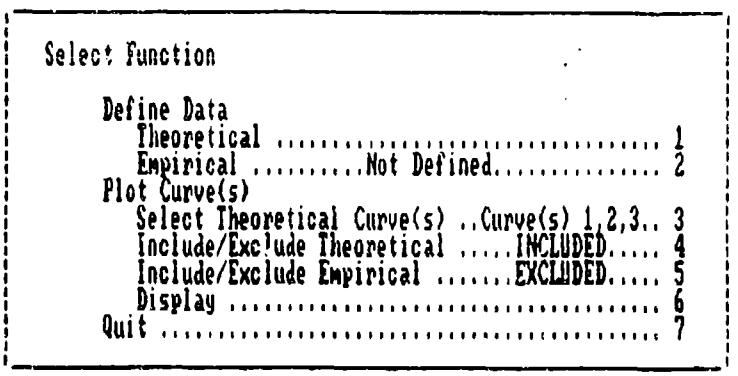


Figure 11. Empirical data definition menu.

The plot functions available to the analyst from the GA main menu include the following:

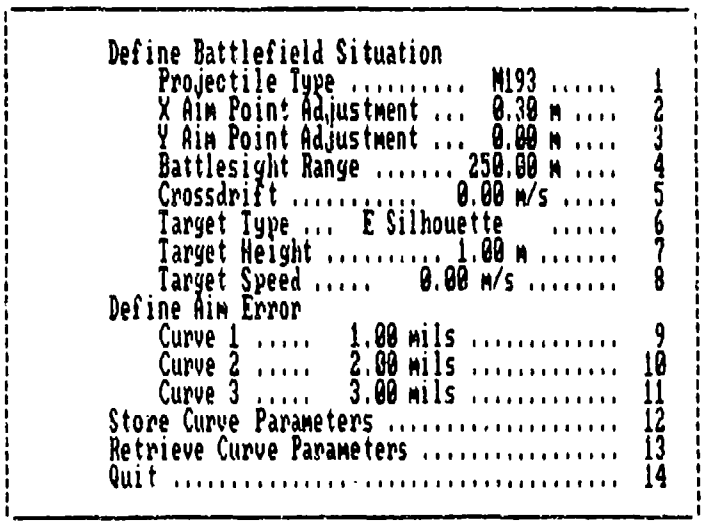
review hit probability data
select curve(s) to plot
include/exclude theoretical and empirical data in a plot
display a plot

In the PA module, the analyst established the probability of hitting a 150-m target given a specified battlefield situation. In the GA module, the analyst can examine hit probability for all targets ranging from 1 to 400 m. Select function 1 to recreate the battlefield situation used in the PA module.

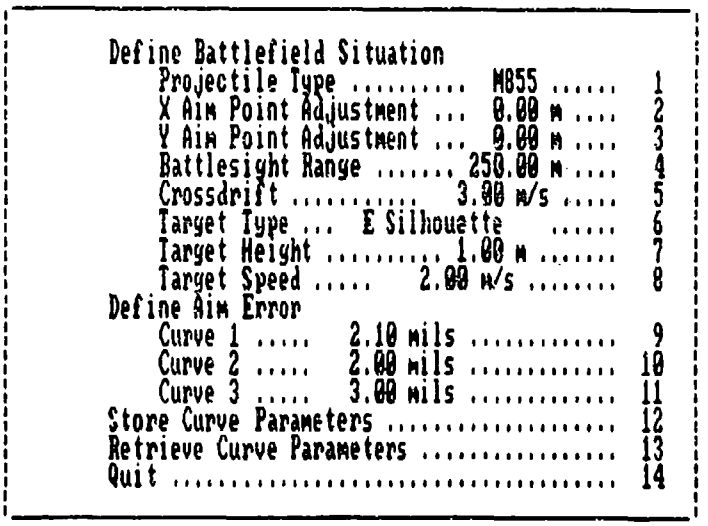


Parameter data are entered the same way as PA module data. Make the following changes to set up the battlefield situation:

M855 projectile
+3.0 meters/sec crossdrift
+2.0 meters/sec target speed
2.10 mils aim error



Use functions 1, 5, 8, and 9 to make the previously stated changes. When the four changes are complete, the display should match the following display. Store the curve parameters using function 12. Select function 14 to quit and return to the GA main menu.



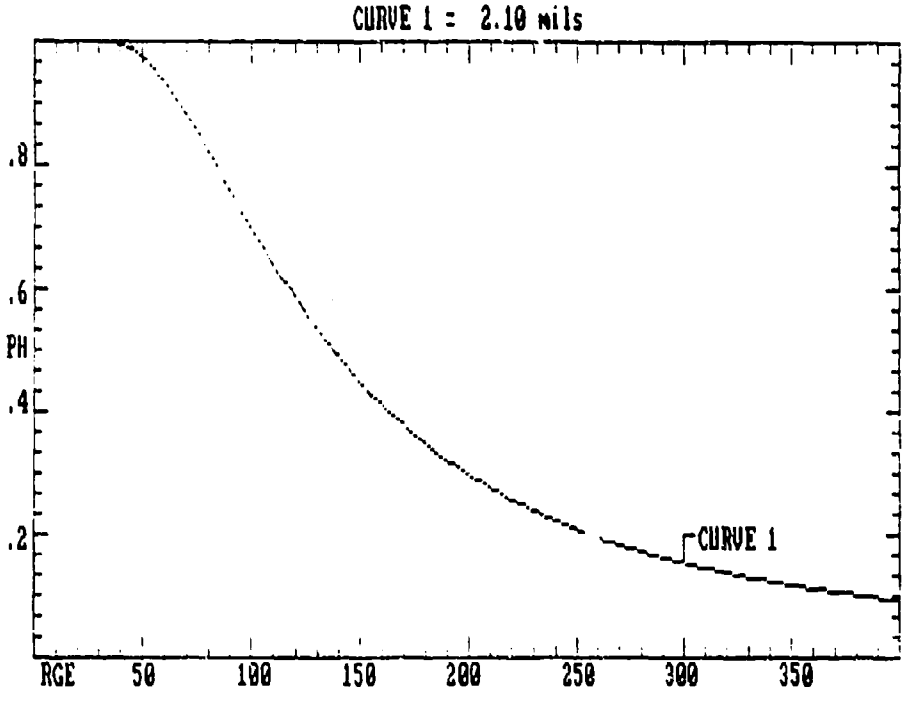
With the battlefield situation established, the analyst can review the theoretical results and can choose which curves to plot. Select function 3 from the GA main menu.

```
Select Function

     Define Data
        Theoretical ..................................... 1
        Empirical .....Not Defined..... 2
     Plot Curve(s)
        Select Theoretical Curve(s) ..Curve(s) 1,2,3.. 3
        Include/Exclude Theoretical .....INCLUDED..... 4
        Include/Exclude Empirical .....EXCLUDED..... 5
        Display ..... 6
     Quit ..... 7

Enter --) ? 3
```

The following display presents hit probability estimates generated by the specified battlefield situation. Estimates are calculated for eight targets beginning with a 50-m target, progressing in 50-m increments to 400 m. MATAS generated three sets of hit probability data based on the three aim error values. The data generated by the 2.10-mil aim error value comprise curve 1. Curves 2 and 3 contain data generated by the default aim error values of 2.0 and 3.0 mils, respectively. The analyst can choose the curve(s) to plot using the functions at the bottom of the display. Enter a 1 to designate curve 1 as the curve to plot.

```
                HIT PROBABILITY BY RANGE AND AIM ERROR

Theoretical Curves      1          2          3
Aim Error (mils)      2.10       2.00       3.00

                                Hit Probability
Range (meters)           %          %          %
     50               1.00       0.98       0.87
    100               0.98       0.73       0.48
    150               0.87       0.48       0.27
    200               0.73       0.32       0.16
    250               0.59       0.22       0.11
    300               0.48       0.16       0.08
    350               0.39       0.12       0.06
    400               0.32       0.10       0.04

Select Theoretical Curve(s) To Display

1 - Curve 1    4 - Curves 1 & 2    7 - Curves 1, 2, & 3
2 - Curve 2    5 - Curves 1 & 3    8 - Quit
3 - Curve 3    6 - Curves 2 & 3

Enter --) ? 1
```

The GA main menu shows that the curve 1 hit probability data will be included in the plot. Since no empirical data were defined, the empirical curve is excluded from the plot. Select function 6 to display curve 1.



This graphic demonstrates how hit probability decreases as range increases given the battlefield situation. What would the curve be if aim error were 3.5 or 5.0 mils? Hit any key to return to the GA main menu.

Select function 1 from the GA main menu. Then select function 10 from the GA parameter menu, and enter an aim error of 3.5 mils.

```
Current Aim Error For 2nd Curve   2.00 mils
Enter (cr) To Keep Current Value
Or Enter New Aim Error (in mils)

Enter --) ? 3.5
```

Select function 12, and enter an aim error of 5.0 mils.

```
Current Aim Error For 3rd Curve   3.00 mils
Enter (cr) To Keep Current Value
Or Enter New Aim Error (in mils)

Enter --) ? 5.0
```

Select function 3 from the GA main menu. From the theoretical curve menu, select option 7 to designate curves 1, 2, and 3 as the curves to display.

HIT PROBABILITY BY RANGE AND AIM ERROR

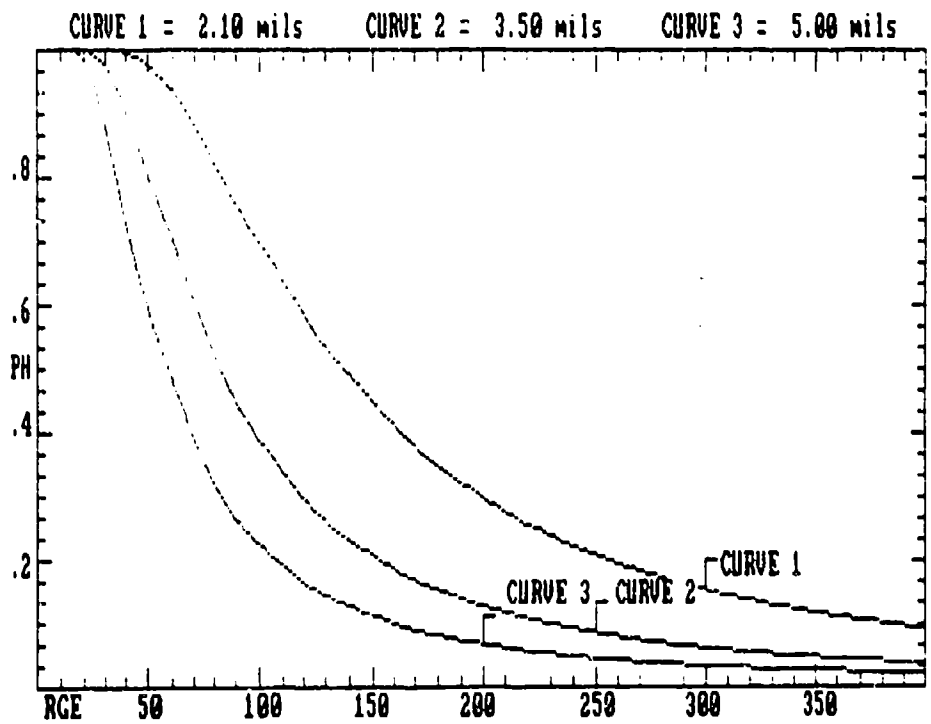
Theoretical Curves	1	2	3
Aim Error (mils)	2.10	3.50	5.00
		Hit Probability	
Range (meters)	%	%	%
50	0.98	0.98	0.87
100	0.70	0.73	0.48
150	0.45	0.48	0.27
200	0.30	0.32	0.16
250	0.21	0.22	0.11
300	0.15	0.16	0.08
350	0.11	0.12	0.06
400	0.09	0.10	0.04

Select Theoretical Curve(s) To Display

1 - Curve 1 4 - Curves 1 & 2 7 - Curves 1, 2, & 3
2 - Curve 2 5 - Curves 1 & 3 8 - Quit
3 - Curve 3 6 - Curves 2 & 3

Enter --> ? 7

Enter option 8 to quit and return to the GA main menu. The main menu shows that all three curves will be included in the plot. Select function 6 to display the hit probability curves, and hit any key to return to the GA main menu.



Empirical Data Definition

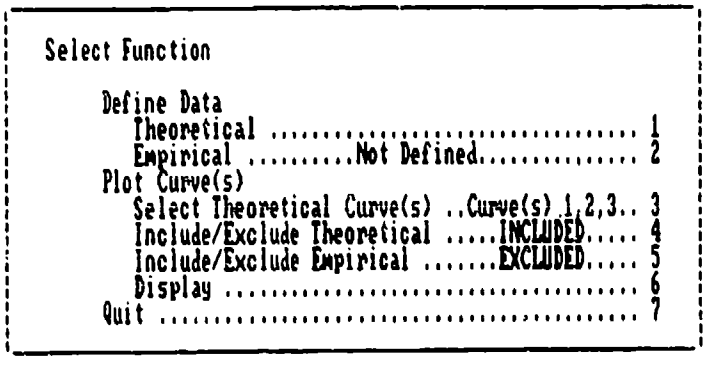
MATAS can also plot empirical target range and hit probability data. Suppose the analyst wanted to examine the data shown in Table 1.

Table 1

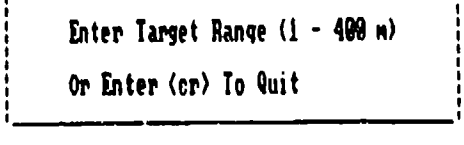
Target Range and Hit Probability Data

Target range (m)	Hit probability
25	1.00
50	1.00
75	0.95
100	0.90
125	0.82
150	0.75
175	0.63
200	0.52
225	0.47
250	0.39
275	0.35
300	0.29
325	0.23
350	0.15
375	0.12
400	0.09

Select function 2 from the GA main menu to bring up the empirical data definition menu.



Select option 1 and enter the 25-m target range.



On the display that follows, enter the corresponding 1.0 hit probability.

```
Enter Hit Probability (0 - 1)

Enter --) ? 1.0
```

Enter the remaining range and hit probability pairs in the same manner. When data entry is complete, enter a <cr> to quit, and review the empirical data summary table.

```
                TABLE OF EMPIRICAL DATA POINTS

   Point          Range          Hit Probability
     #        (1 - 400 m)           (0 - 1)
-------------------------------------------------
     1             25               1.00
     2             50               1.00
     3             75               0.95
     4            100               0.90
     5            125               0.82
     6            150               0.75
     7            175               0.63
     8            200               0.52
     9            225               0.47
    10            250               0.39
-------------------------------------------------
                Continued Next Page

1 - Page 1        4 - Add          7 - Retrieve
2 - Page 2        5 - Delete       8 - Store
3 - Page 3        6 - Modify       9 - Quit

Enter --) ? 2
```

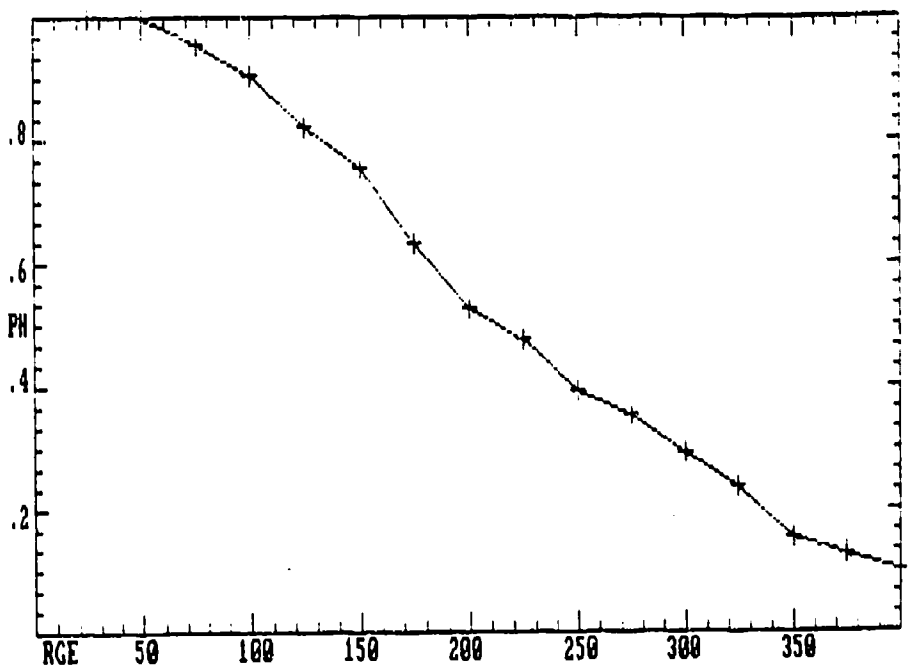
The summary table presents the first 10 data pairs. Select option 2 to review the remaining data.

```
                TABLE OF EMPIRICAL DATA POINTS

   Point          Range          Hit Probability
     #        (1 - 400 m)           (0 - 1)
-------------------------------------------------
    11            275              0.35
    12            300              0.29
    13            325              0.23
    14            350              0.15
    15            375              0.12
    16            400              0.09
-------------------------------------------------

1 - Page 1        4 - Add          7 - Retrieve
2 - Page 2        5 - Delete       8 - Store
3 - Page 3        6 - Modify       9 - Quit

Enter --) ? 8
```

Correct any data entry errors using the add, delete, and modify edit functions. When satisfied with the accuracy of the data, use function 8 to store the data. Select option 9 to quit when editing is complete.

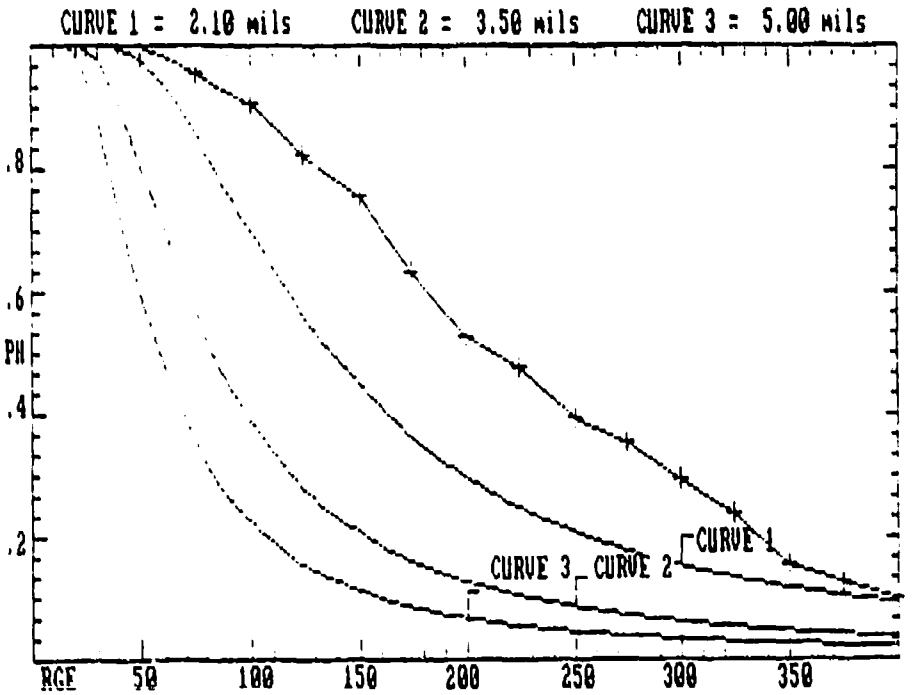
```
Select Function

     Define Data
        Theoretical ..................................... 1
        Empirical ..... Defined ......................... 2
     Plot Curve(s)
        Select Theoretical Curve(s) ..Curve(s) 1,2,3.. 3
        Include/Exclude Theoretical .....EXCLUDED..... 4
        Include/Exclude Empirical .......INCLUDED..... 5
        Display ......................................... 6
     Quit ............................................... 7

Enter --> ? 6
```

On the GA main menu, toggle functions 4 and 5 to exclude the theoretical curves, and include the empirical curve in the plot. Select function 6 to display the empirical curve.



The analyst may want to determine the approximate aim error associated with this empirical hit probability curve. This is accomplished in the GA module by plotting several theoretical curves with analyst-defined aim error values. Through this trial-and-error process, the analyst is essentially performing a curve fitting function which yields an estimate of aim error. Hit any key to return to the GA main menu.

From the main menu, toggle function 4 to include the theoretical curves in the plot. Select function 6 to display all four curves.



Inspection of the four curves reveals that curve 1, with an aim error of 2.10 mils, most closely approximates the empirical curve. The empirical curve appears to be 3/4 mil less than the curve 1 aim error. To obtain a better estimate, the analyst can change the aim error values for the theoretical curves to move them closer to the empirical curve. Hit any key to return to the GA main menu.

Select function 1 to enter the GA parameter menu. Select functions 9 and 10 from the parameter menu to change the curve 1 and curve 2 aim error values to 1.0 and 1.5 mils, respectively. When these changes are complete, select function 14 to return to the GA main menu.

```
Define Battlefield Situation
    Projectile Type ..... M855 .....  1
    X Aim Point Adjustment ... 0.00 M ....  2
    Y Aim Point Adjustment ... 0.00 M ....  3
    Battlesight Range ..... 250.00 M ....  4
    Crossdrift ..... 3.00 M/S .....  5
    Target Type ... E Silhouette .....  6
    Target Height ..... 1.00 M .....  7
    Target Speed ..... 2.00 M/S .....  8
Define Aim Error
    Curve 1 ..... 1.00 mils .....  9
    Curve 2 ..... 1.50 mils ..... 10
    Curve 3 ..... 5.00 mils ..... 11
Store Curve Parameters ..... 12
Retrieve Curve Parameters ..... 13
Quit ..... 14

Enter --) ? 14
```

From the GA main menu, select function 3 to enter the theoretical curve menu. Select option 4 to designate curves 1 and 2 as the curves to plot. Select function 8 to quit and return to the GA main menu.

HIT PROBABILITY BY RANGE AND AIM ERROR

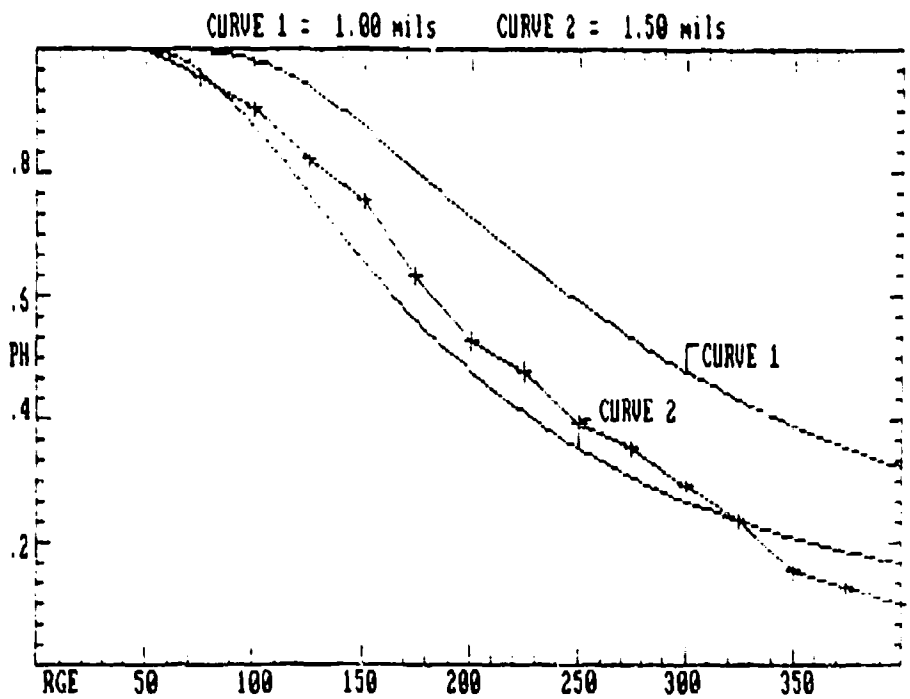
Theoretical Curves	1	2	3
Aim Error (mils)	1.00	1.50	5.00
		Hit Probability	
Range (meters)	%	%	%
50	1.00	1.00	0.99
100	0.94	0.87	0.80
150	0.76	0.66	0.56
200	0.59	0.48	0.39
250	0.45	0.35	0.28
300	0.35	0.27	0.21
350	0.28	0.21	0.16
400	0.22	0.16	0.12

Select Theoretical Curve(s) To Display

1 - Curve 1 4 - Curves 1 & 2 7 - Curves 1, 2, & 3
2 - Curve 2 5 - Curves 1 & 3 8 - Quit
3 - Curve 3 6 - Curves 2 & 3

Enter --) ? 4

Select function 6 to display the curves.



Theoretical hit probability curve 2 closely approximates the empirical curve. From this, the analyst can conclude that the aim error associated with this data set is slightly less than 1.5 mils.

The preceding exercises provide the analyst with an understanding of MATAS capabilities. These exercises show how MATAS functions as a tool which can analyze the functional relationship between aiming and tracking performance and a variety of weapon system and battlefield parameters.

REFERENCES

Cuddeback, J. B., Cuccarese, G. K., Maxey, J. L., Torre, J. P., Jr., & Reinhartz, S. (1987). Simulated marksmanship performance with the M16A1 rifle, aiming error study phase I-B: Aiming error as a function of practice and firing position. Manuscript submitted for publication.

Maxey, J. L., Torre, J. P., Jr., Cuddeback, J. B., Cuccarese, G. K., & Reinhartz, S. (1986). Simulated marksmanship performance with the M16A1 rifle, aiming error study phase I: Aiming error as a function of practice and firing position. Manuscript submitted for publication.

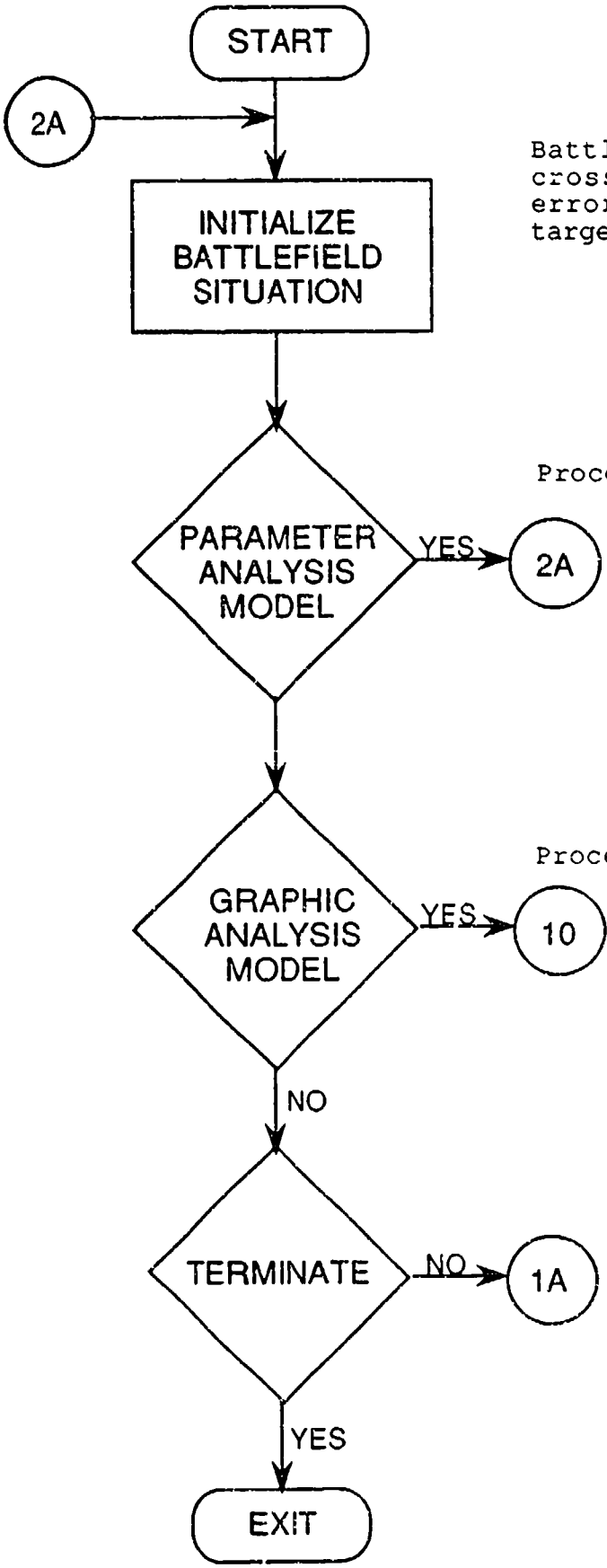
Maxey, J. L., Torre, J. P., Jr., Cuddeback, J. B., Cuccarese, G. K., & Reinhartz, S. (1986). Simulated marksmanship performance with the M16A1 rifle, aiming error study phase II: Aiming error as a function of practice and firing position. Manuscript submitted for publication.

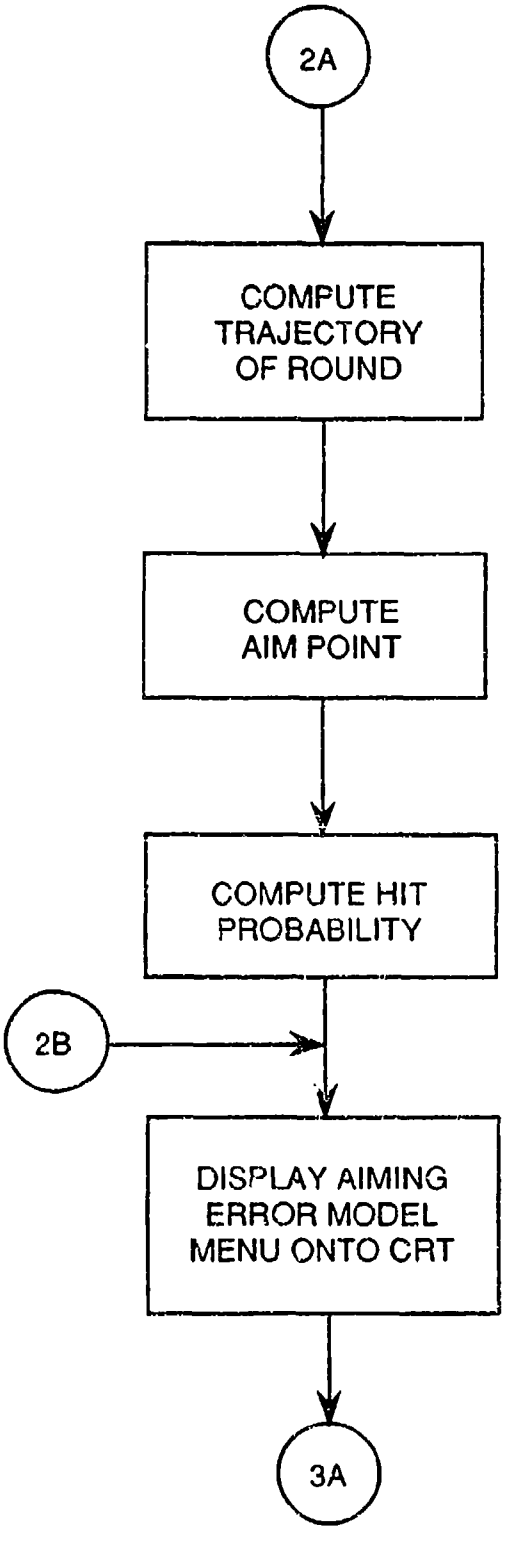
Pipes, L., & Harvill, L. (1970). Applied mathematics for engineers and physicists. New York: McGraw Hill.

U.S. Army Development and Readiness Command. (1977). Engineering design handbook: Army weapon systems analysis, Part I (DARCOM Pamphlet No. P-706-101). Alexandria, VA: Author.

APPENDIX A

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM FLOW CHART


START
2A
INITIALIZE BATTLEFIELD SITUATION
Battlesight range, target range, cross drift, target speed, aim error, target type, round type, target dimensions, x,y aim point
PARAMETER ANALYSIS MODEL
YES
2A
Process parameter analysis model
GRAPHIC ANALYSIS MODEL
YES
10
Process graphic analysis model
NO
TERMINATE
NO
1A
YES
EXIT

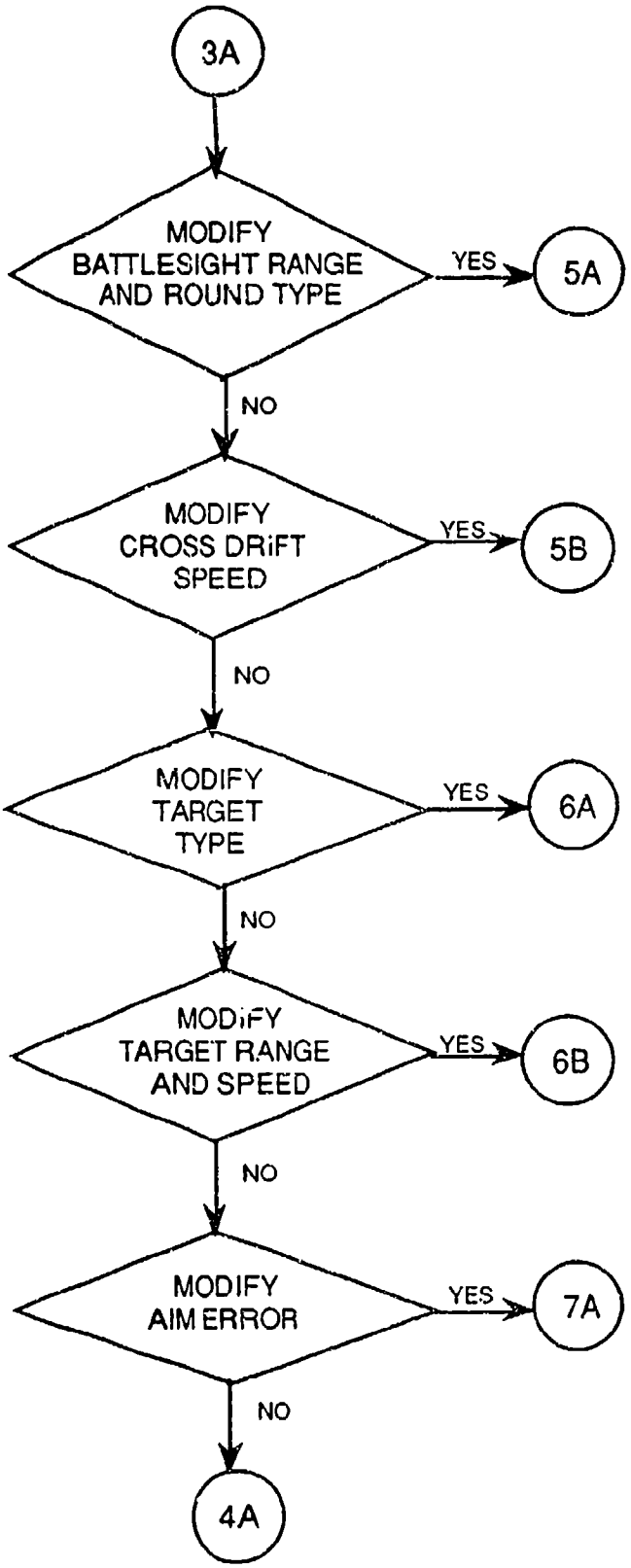


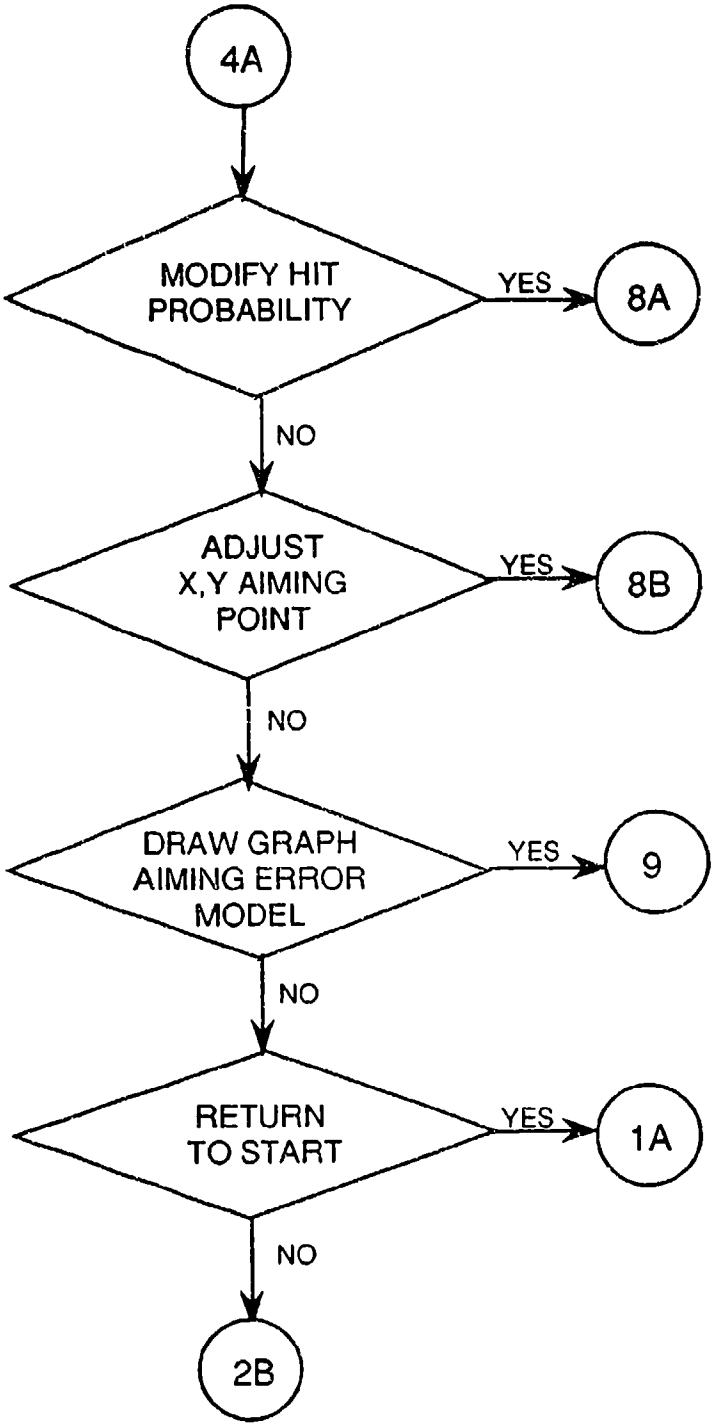
Purpose: Defines round type characteristics and computes the trajectory in x and y, time of flight, and velocity of round.
Inputs: Battlesight and target range, round characteristics, cross drift.
Outputs: X and y trajectory and offsets to that trajectory.

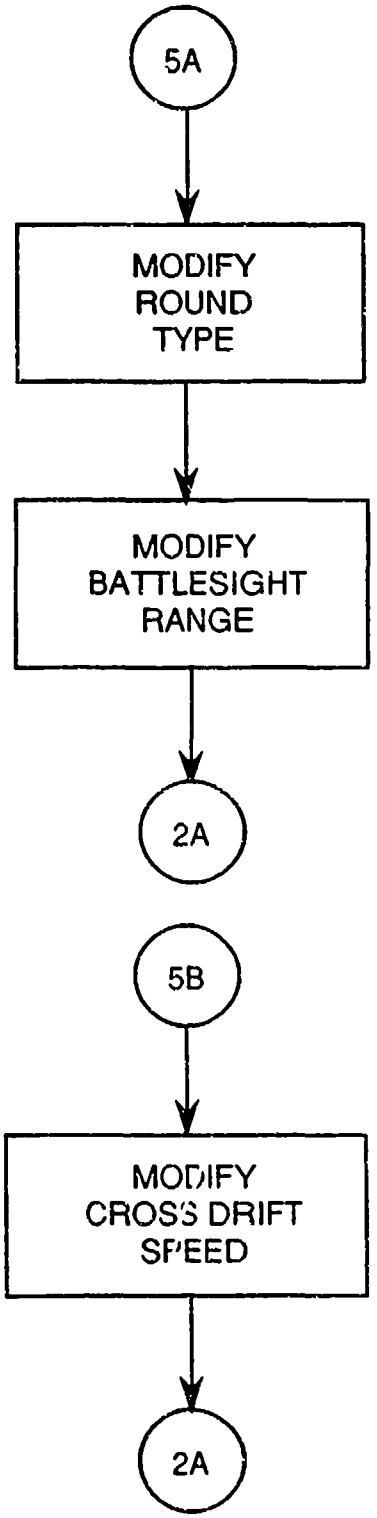
Purpose: Adjusts aim point on target based on x and y trajectory and offsets to that trajectory.
Inputs: X and y trajectory and offsets to trajectory.
Outputs: X and y aim point.

Purpose: Computes hit probability.
Inputs: Target dimensions, x and y aim point, and radial standard deviation.
Outputs: Hit probability.

Purpose: Defines parameter analysis model status, allows changes in battlefield situation.
Inputs: Battlesight and target range, round and target type, cross drift, target speed, aim error, hit probability, aim point, adjustment to aim point, time of flight, velocity of round, initial pitch angle of round, target dimensions.
Outputs: Parameter analysis model status and selected function.


3A
MODIFY BATTLESIGHT RANGE AND ROUND TYPE
YES
5A
NO
MODIFY CROSS DRIFT SPEED
YES
5B
NO
MODIFY TARGET TYPE
YES
6A
NO
MODIFY TARGET RANGE AND SPEED
YES
6B
NO
MODIFY AIM ERROR
YES
7A
NO
4A

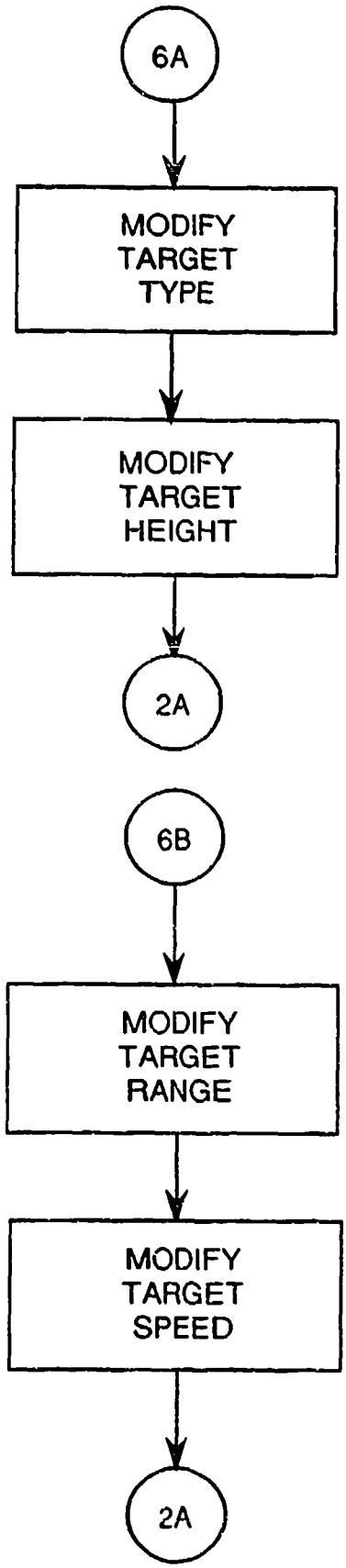

4A
MODIFY HIT PROBABILITY
YES
8A
NO
ADJUST X,Y AIMING POINT
YES
8B
NO
DRAW GRAPH AIMING ERROR MODEL
YES
9
NO
RETURN TO START
YES
1A
NO
2B



Purpose: To change or view current round type
Input: Round type
Output: Round type

Purpose: To change or view current battle-sight range
Input: Battlesight range
Output: Battlesight range

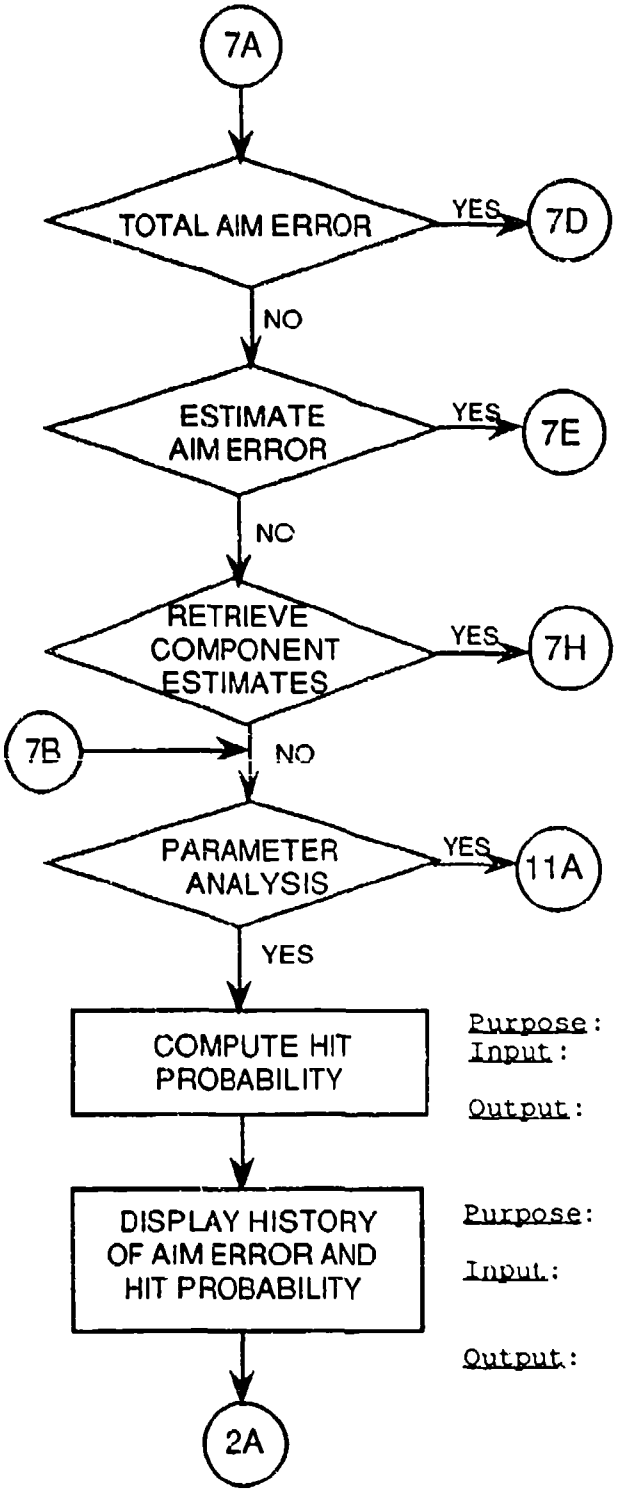
Purpose: To change or view currenct cross drift speed.
Input: Cross drift speed
Output: Cross drift speed



Purpose: To change or view current target type
Input: Target type
Output: Target type

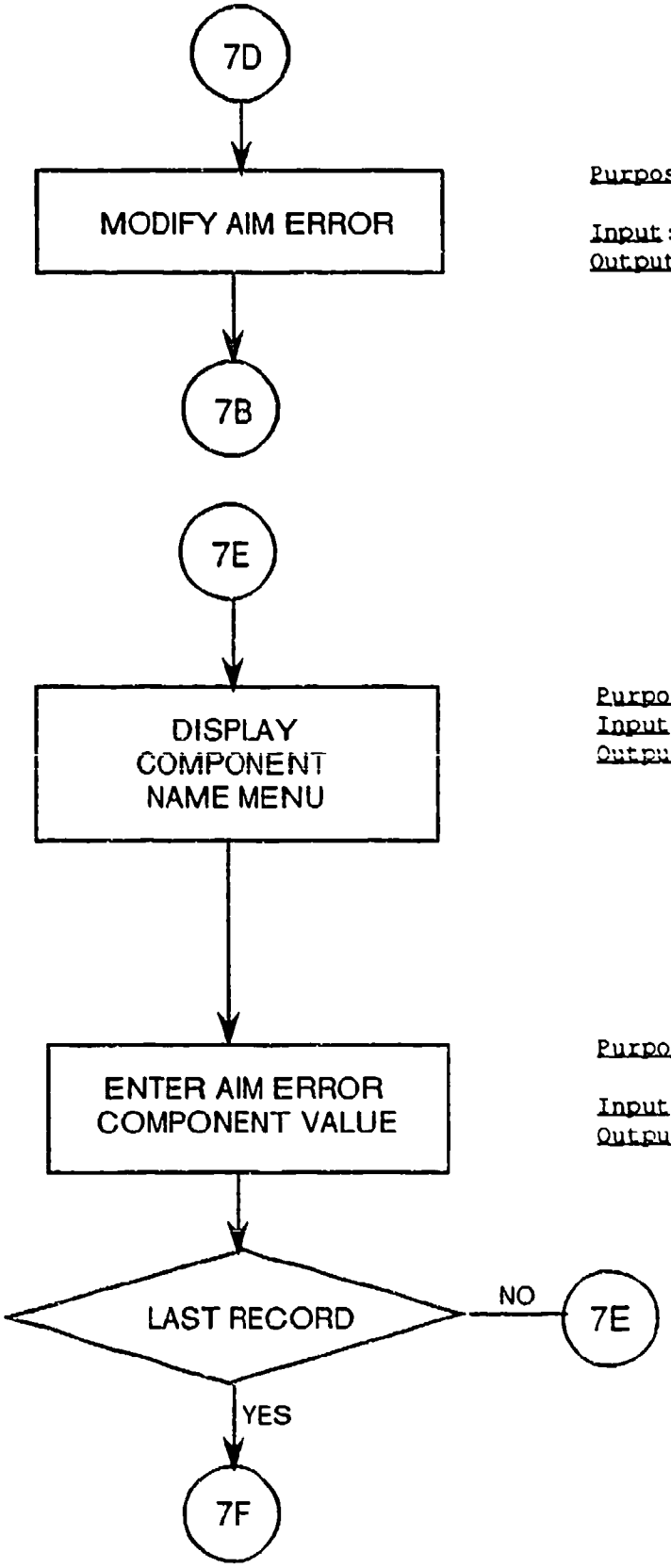
Purpose: To change or view current target height
Input: Target height
Output: Target height

Purpose: To change or view currenct target speed
Input: Target speed
Output: Target speed



Purpose: Compute hit probability
Input: Target dimensions, x,y aim point, and linear aim error
Output: Hit probability

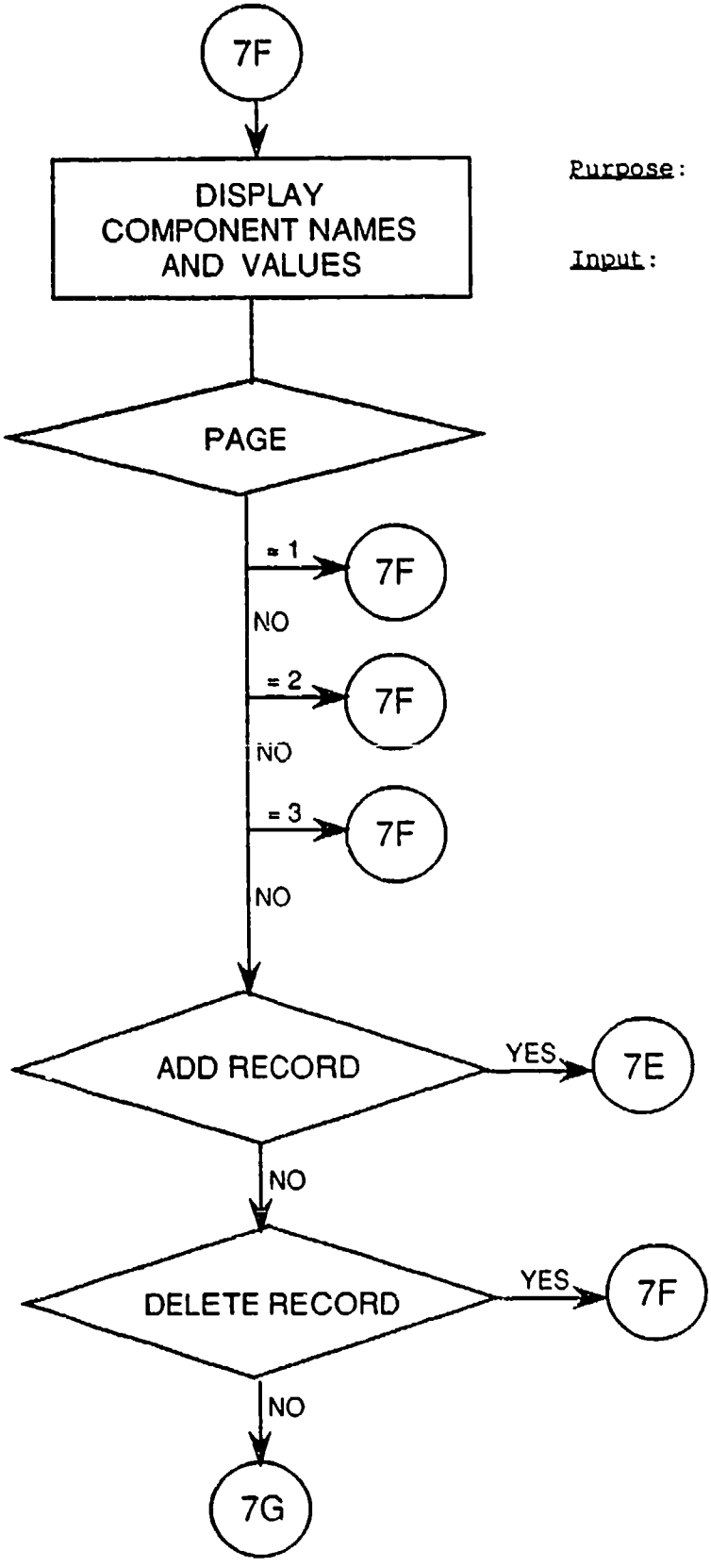
Purpose: Displays history of aim error with associated hit probability
Input: Initial, user-defined, and final aim error and their associated hit probability
Output: Displays initial, user-defined, and final aim error with associated hit probability



Purpose: To change or view current aim error
Input: Total aim error
Output: Total aim error

Purpose: To name aim error component
Input: N/A
Output: Screen display and component identification

Purpose: To identify value associated with component name
Input: Component name
Output: Component name

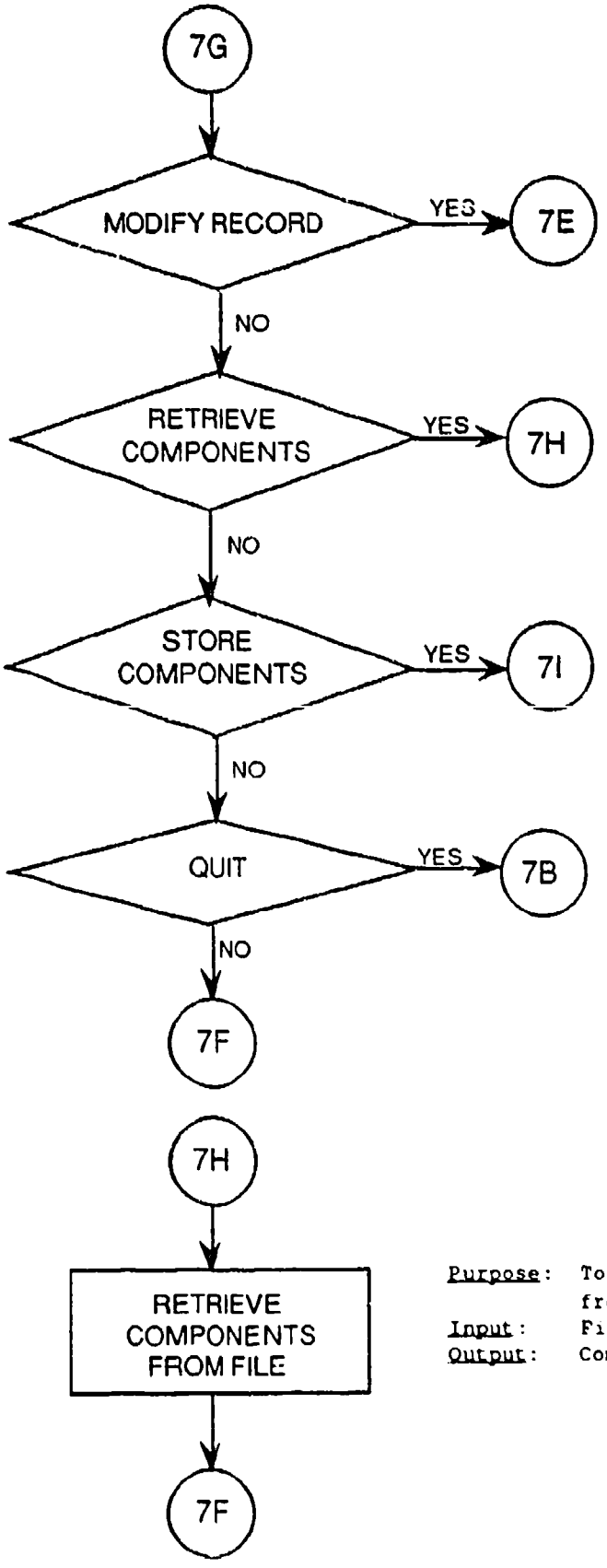


Purpose: Displays 10 component names and values depending on page number

Input: Page number, component names and values

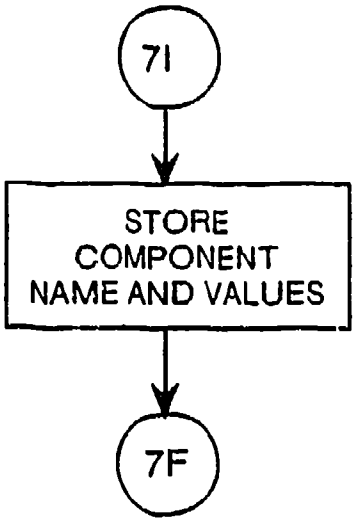
LAST RECORD SET

DELETES SPECIFIED RECORD



LAST RECORD SET

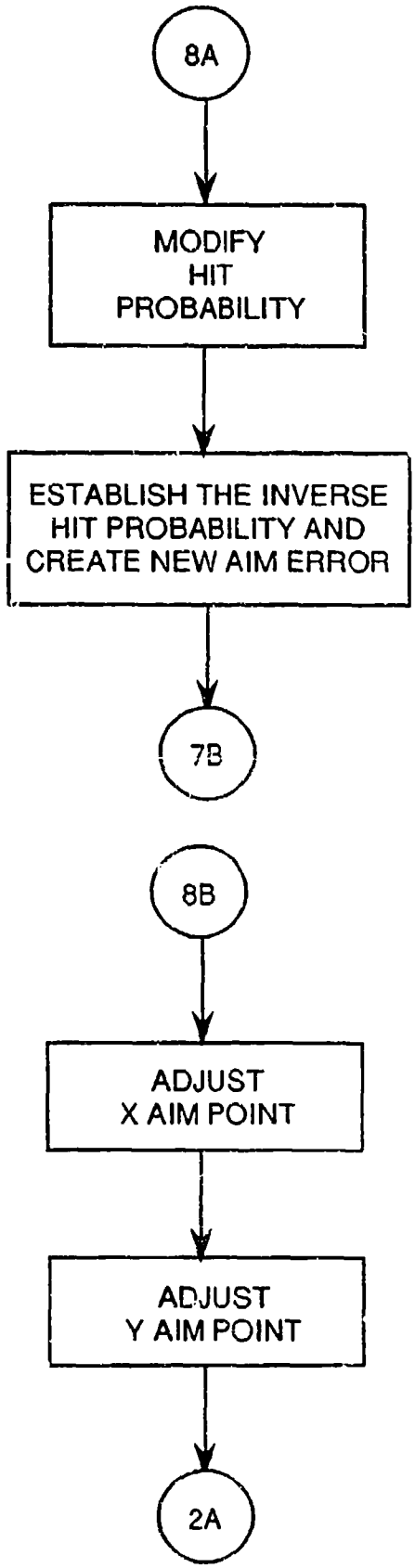
Purpose: To retrieve component name and values from file
Input: File identification
Output: Component name and values



Purpose: To store component names and values in file "ACDAM.EST" or "AEMOL.EST"

Input: File identification, component names and values

Output: N/A

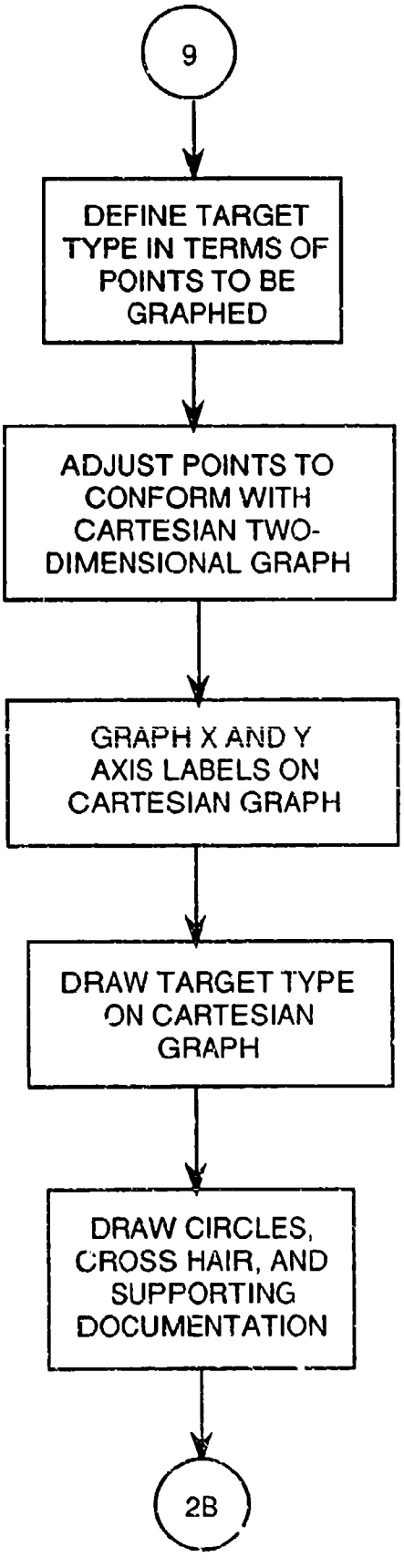


Purpose: To change or view current hit probability
Input: Hit probability
Output: Hit probability

Purpose: Computes new aim error based on desired hit probability
Input: Hit probability and equivalent area circle of the target type
Output: Aim error

Purpose: To change or view current x aim point adjustment
Input: X aim point adjustment
Output: X aim point adjustment

Purpose: To change or view current y aim point adjustment
Input: Y aim point adjustment
Output: Y aim point adjustment

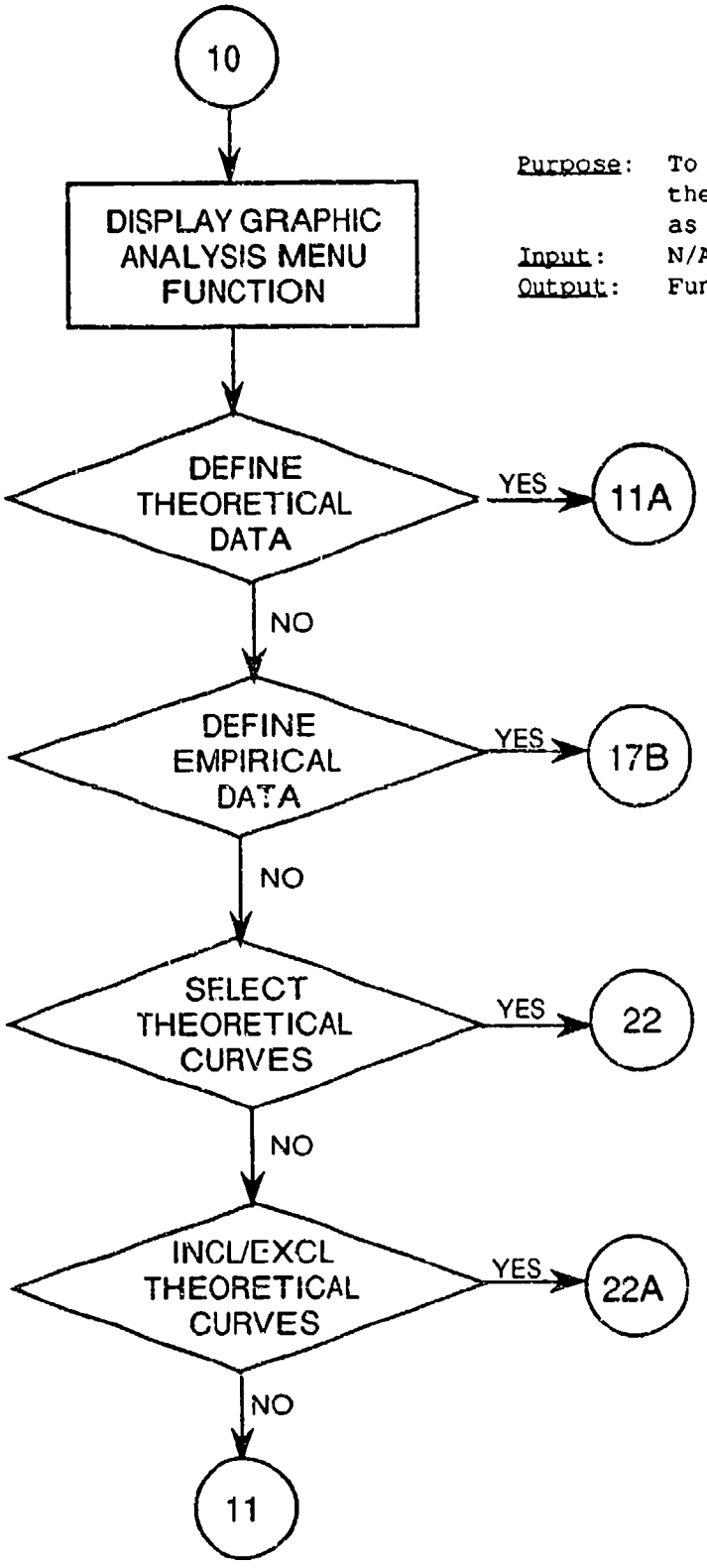


Purpose: To scale and translate target points onto Cartesian graph
Input: Target shape in screen coordinate data
Output: Adjusted target coordinate data, screen display two-dimensional Cartesian graph

Purpose: To output x,y axis labels
Input: None
Output: Screen display

Purpose: To output target shape onto screen
Input: Adjusted target coordinate data
Output: Screen display

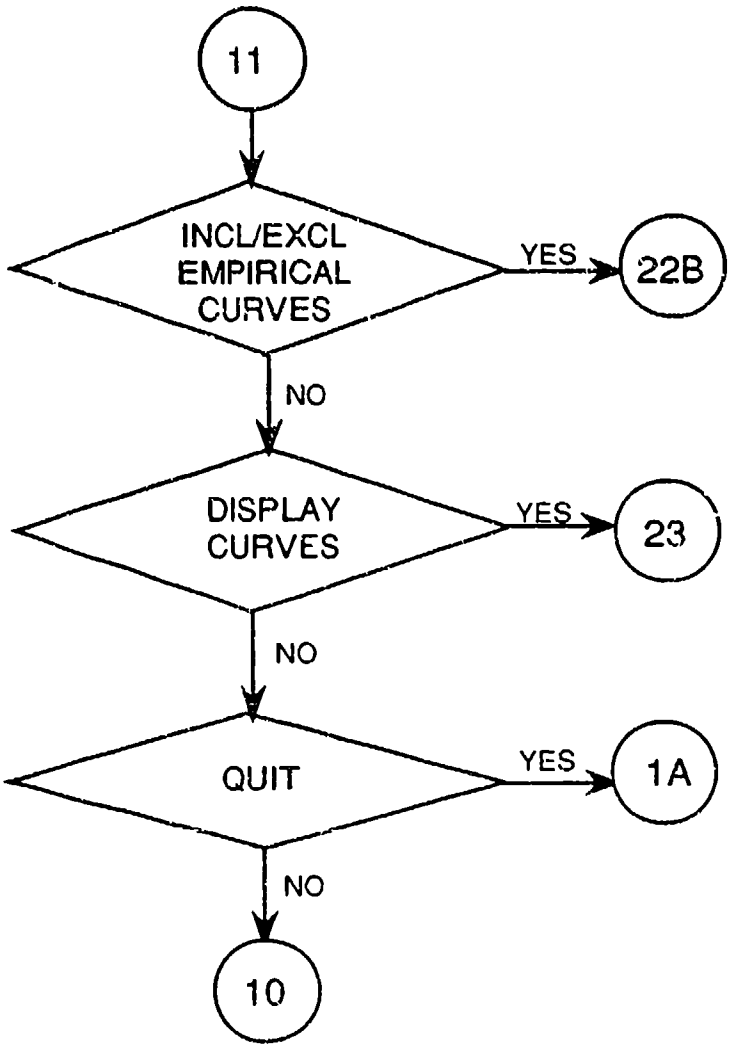
Purpose: To output 40,86,99% circles, aim point, and supporting documentation to screen
Input: X,y aim point
Output: Screen display

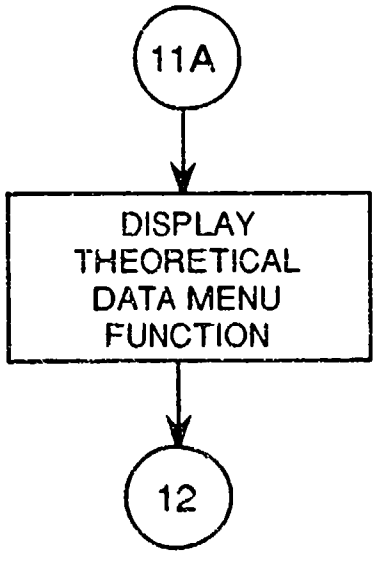


Purpose: To allow user to define theoretical/empirical data as well as graph those data

Input: N/A

Output: Function code, screen display

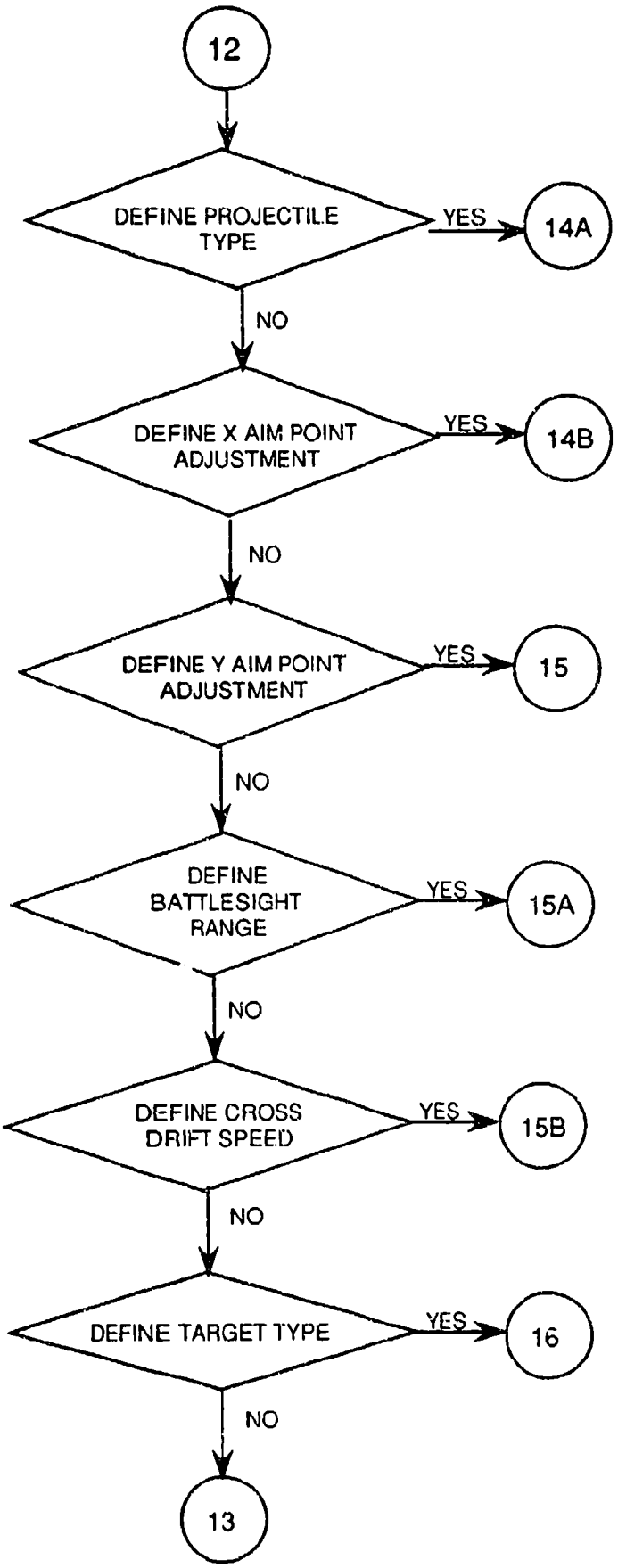


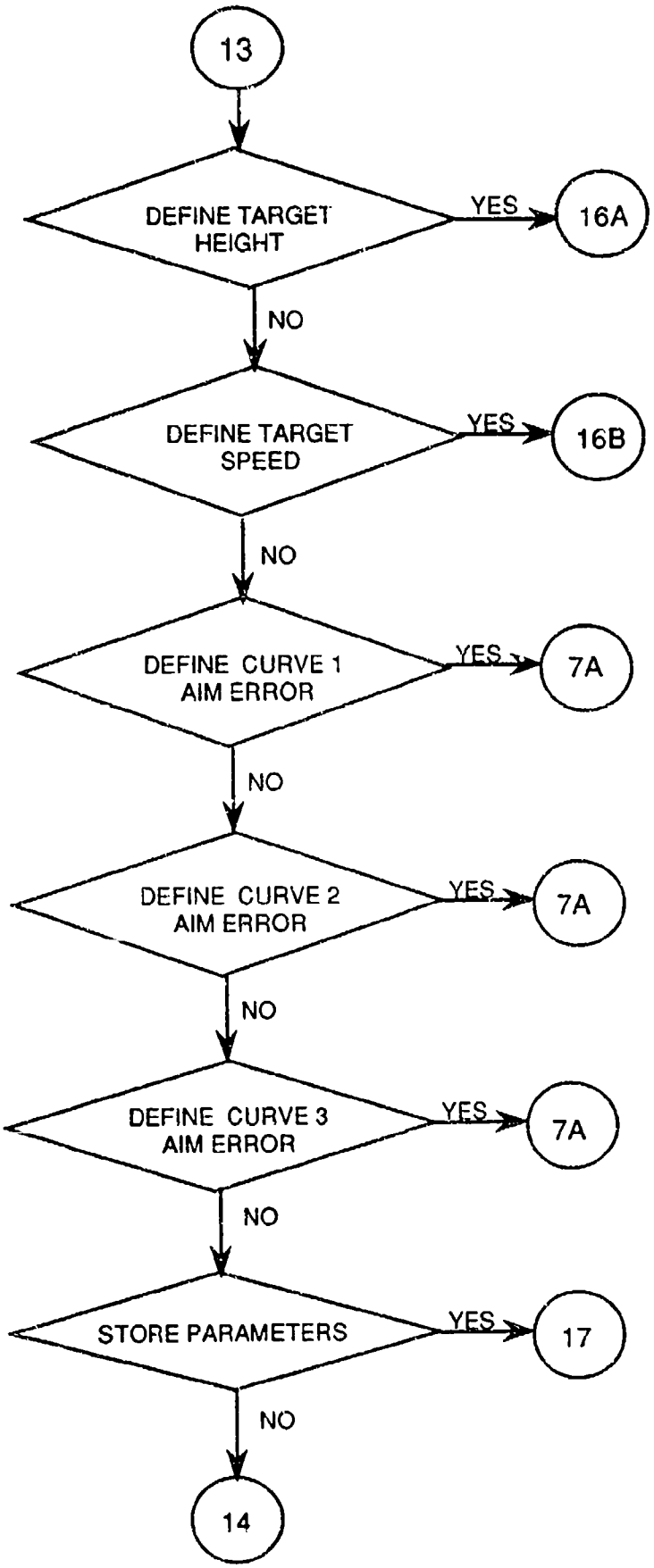


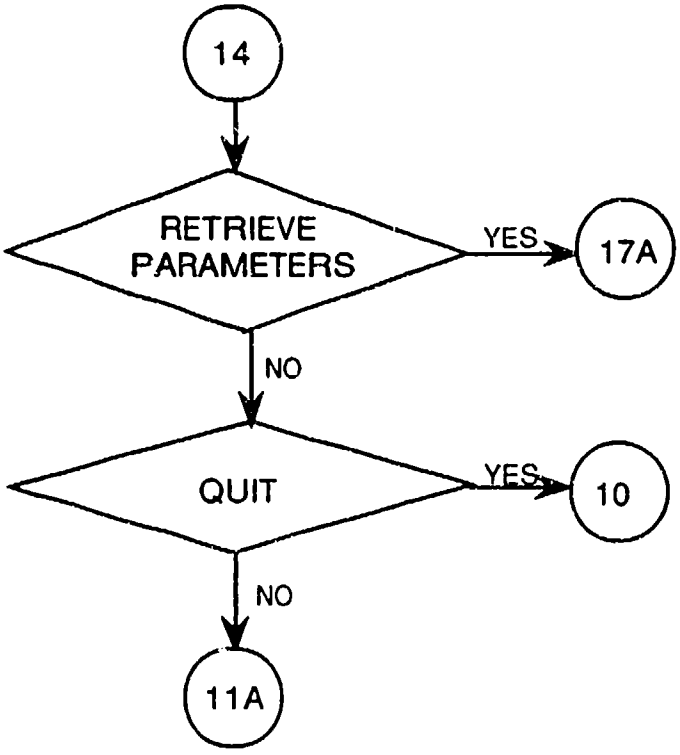
Purpose: To display function menu of system parameters as well as their current status

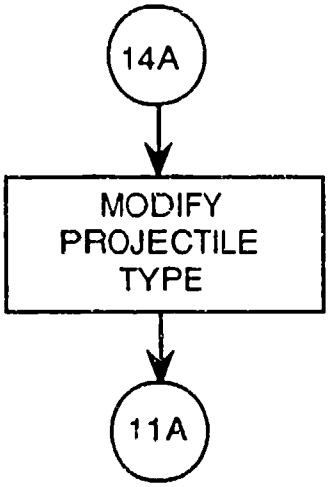
Input: Projectile type, x,y aim point adjustment battlesight range, cross drift, target type, target height, target speed, curve 1,2,3 aim error

Output: Screen display, function identification

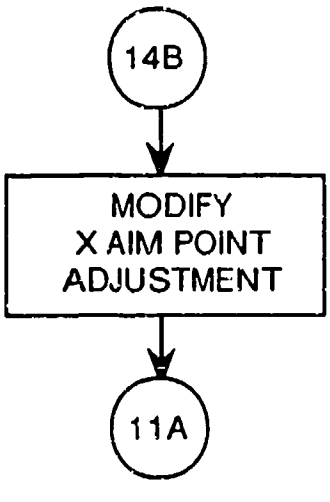

12
DEFINE PROJECTILE TYPE
YES
14A
NO
DEFINE X AIM POINT ADJUSTMENT
YES
14B
NO
DEFINE Y AIM POINT ADJUSTMENT
YES
15
NO
DEFINE BATTLESIGHT RANGE
YES
15A
NO
DEFINE CROSS DRIFT SPEED
YES
15B
NO
DEFINE TARGET TYPE
YES
16
NO
13


13
DEFINE TARGET HEIGHT
YES
16A
NO
DEFINE TARGET SPEED
YES
16B
NO
DEFINE CURVE 1 AIM ERROR
YES
7A
NO
DEFINE CURVE 2 AIM ERROR
YES
7A
NO
DEFINE CURVE 3 AIM ERROR
YES
7A
NO
STORE PARAMETERS
YES
17
NO
14

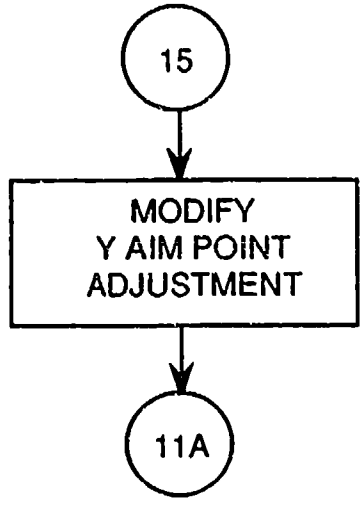




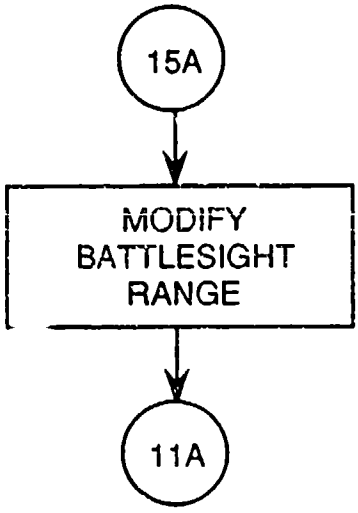
Purpose: To change or view current projectile type
Input: Projectile type
Output: Projectile type



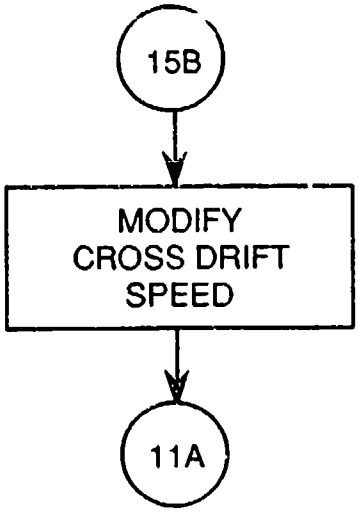
Purpose: To change or view current x aim point adjustment
Input: X aim point adjustment
Output: X aim point adjustment



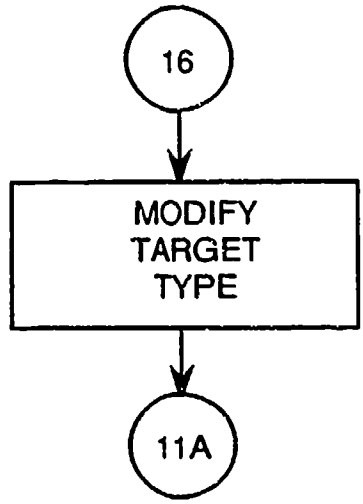
Purpose: To change or view current y aim point adjustment
Input: Y aim point adjustment
Output: Y aim point adjustment



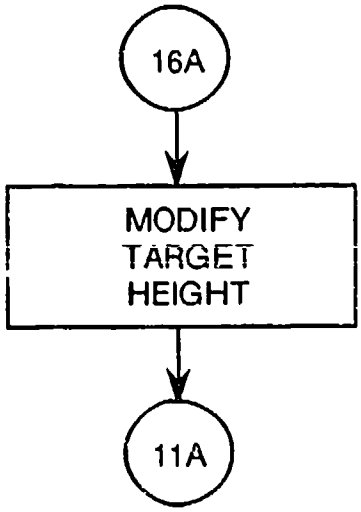
Purpose: To change or view current battlesight range
Input: Battlesight range
Output: Battlesight range



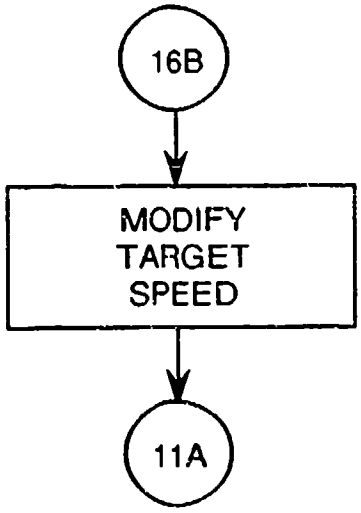
Purpose: To change or view current cross drift speed
Input: Cross drift speed
Output: Cross drift speed



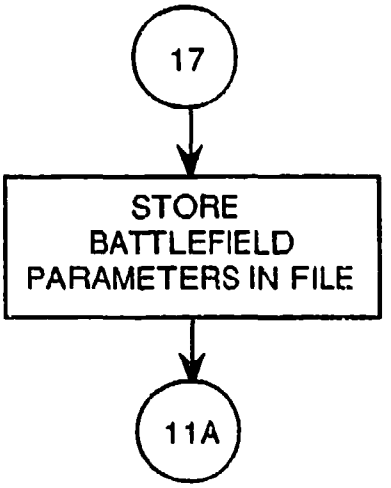
Purpose: To change or view current target type
Input: Target type
Output: Target type



Purpose: To change or view current target height
Input: Target height
Output: Target height



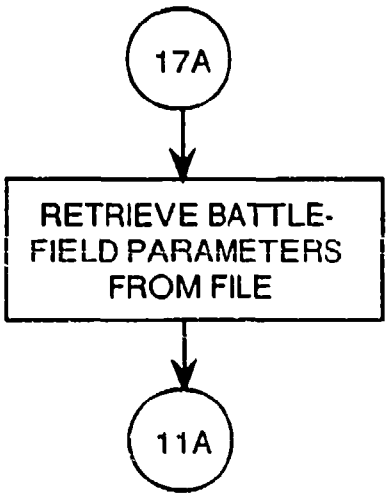
Purpose: To change or view current target speed
Input: Target speed
Output: Target speed



Purpose: To store battlefield situation parameter data and aim error for each curve in file "BATCOND.DAT"

Input: Projectile type and identification code, x,y aim point adjustment, battlesight range, cross drift speed, target type and identification code, target dimensions, target speed, and aim error for curves 1,2,and 3.

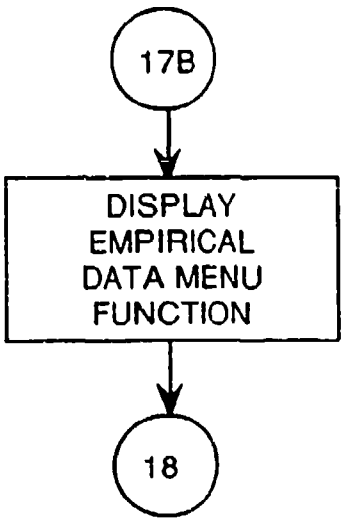
Output: "BATCOND.DAT"



Purpose: To retrieve battlefield situation parameter data and aim error for each curve in file "BATCOND.DAT"

Input: N/A

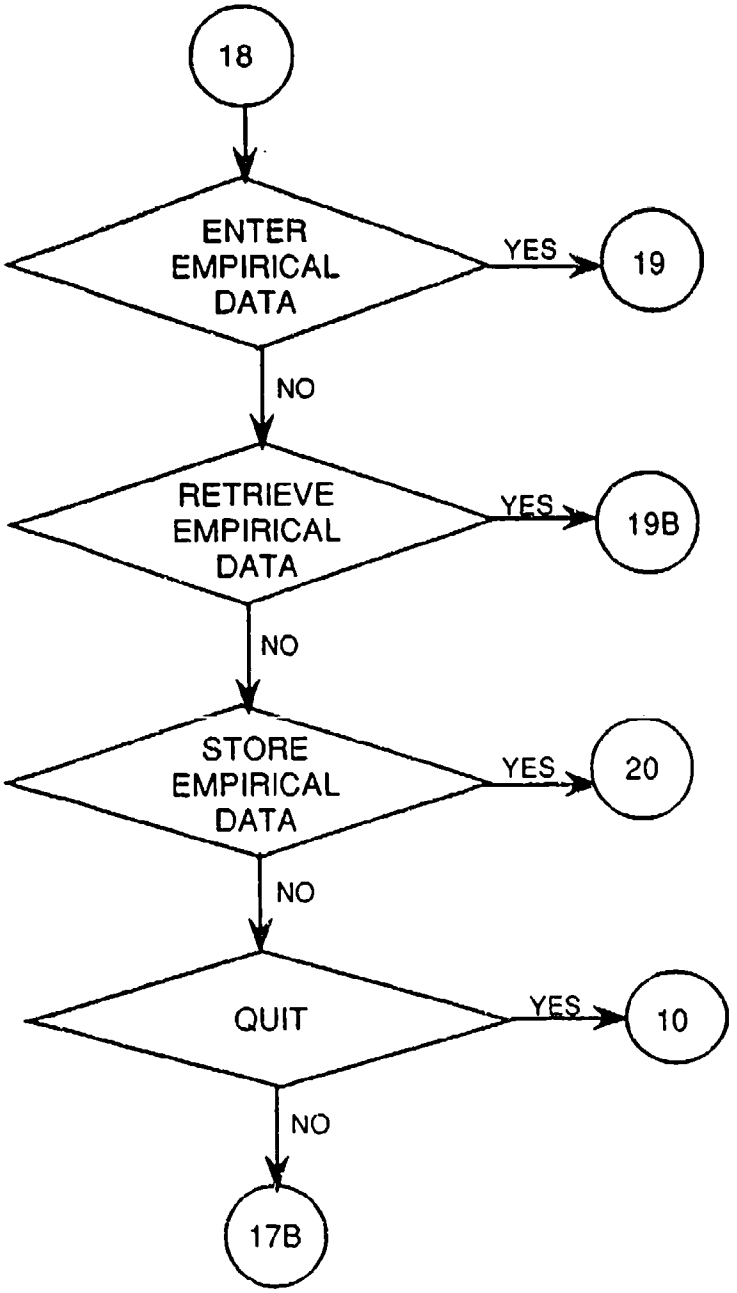
Output: Projectile type and identification code, x,y aim point adjustment, battlesight range, cross drift speed, target type and identification code, target dimensions, target speed, and aim error for curves 1,2,and 3.

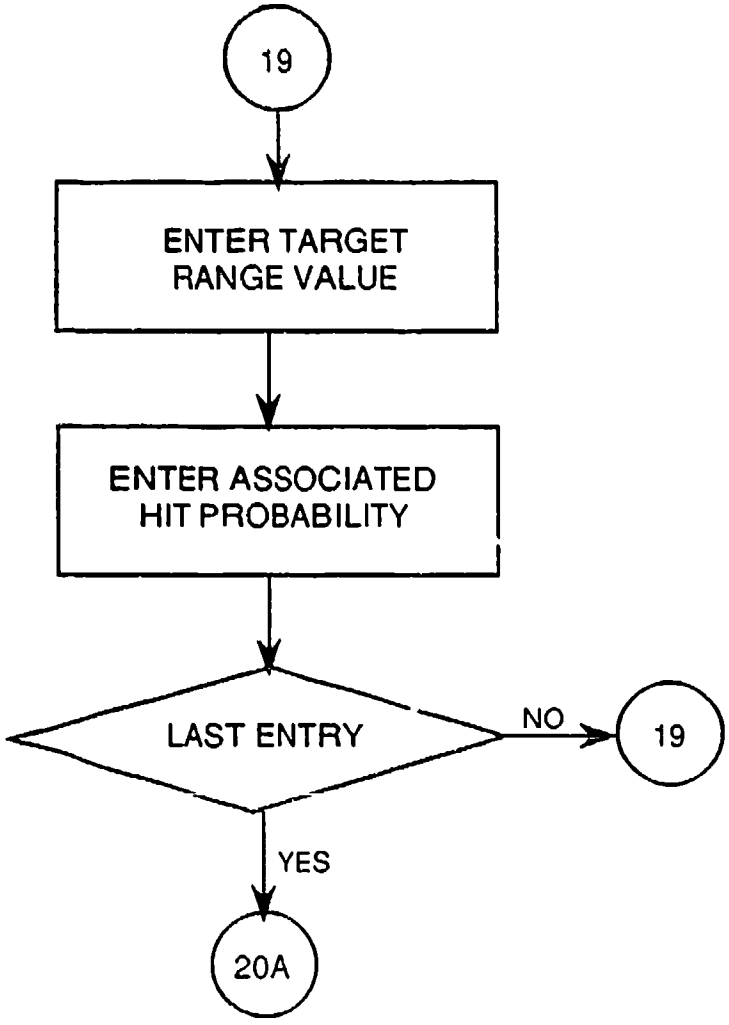


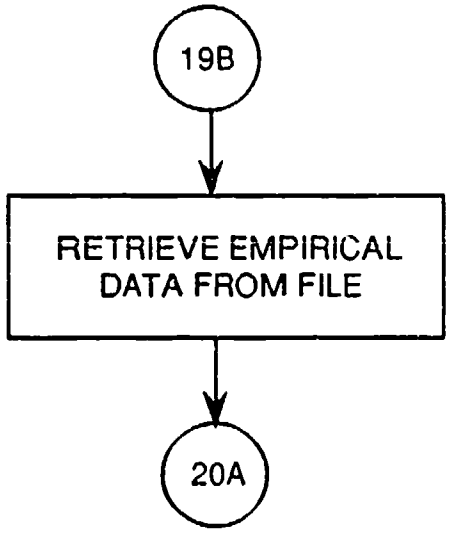
Purpose: To display empirical function menu

Input: N/A

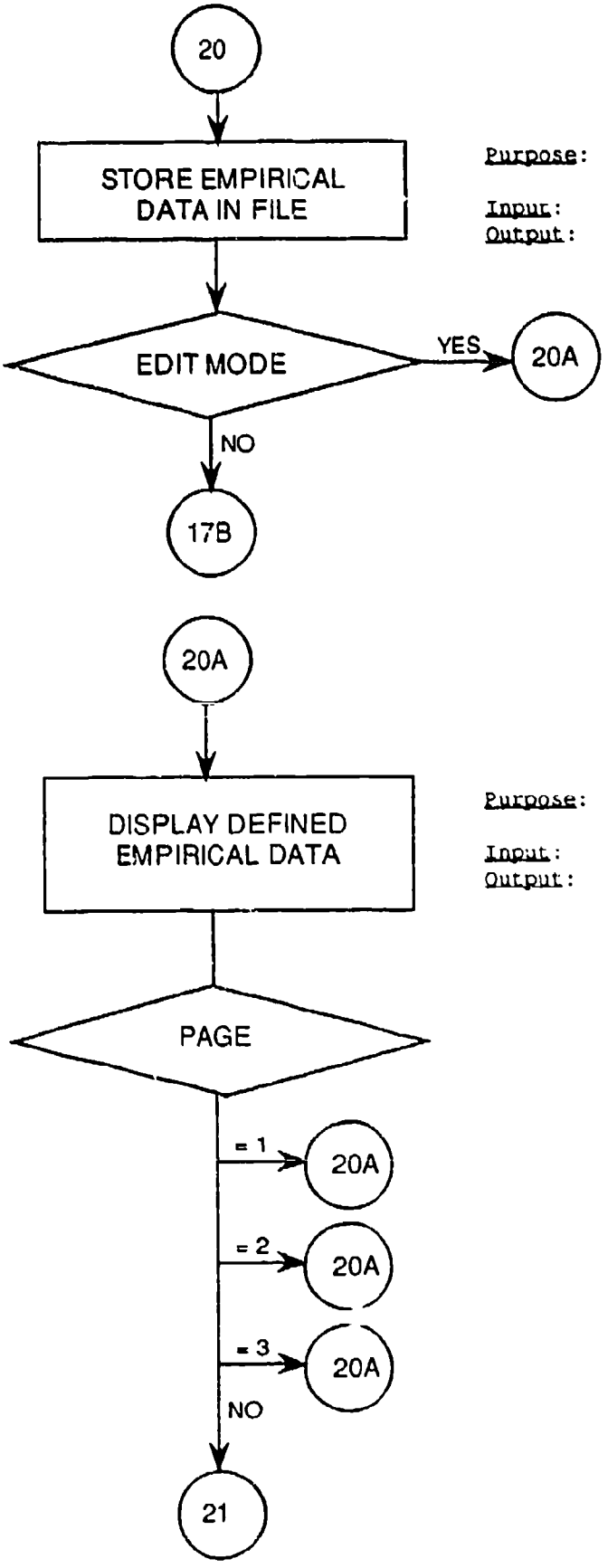
Output: Screen display, function identification


18
ENTER EMPIRICAL DATA
YES
19
NO
RETRIEVE EMPIRICAL DATA
YES
19B
NO
STORE EMPIRICAL DATA
YES
20
NO
QUIT
YES
10
NO
17B



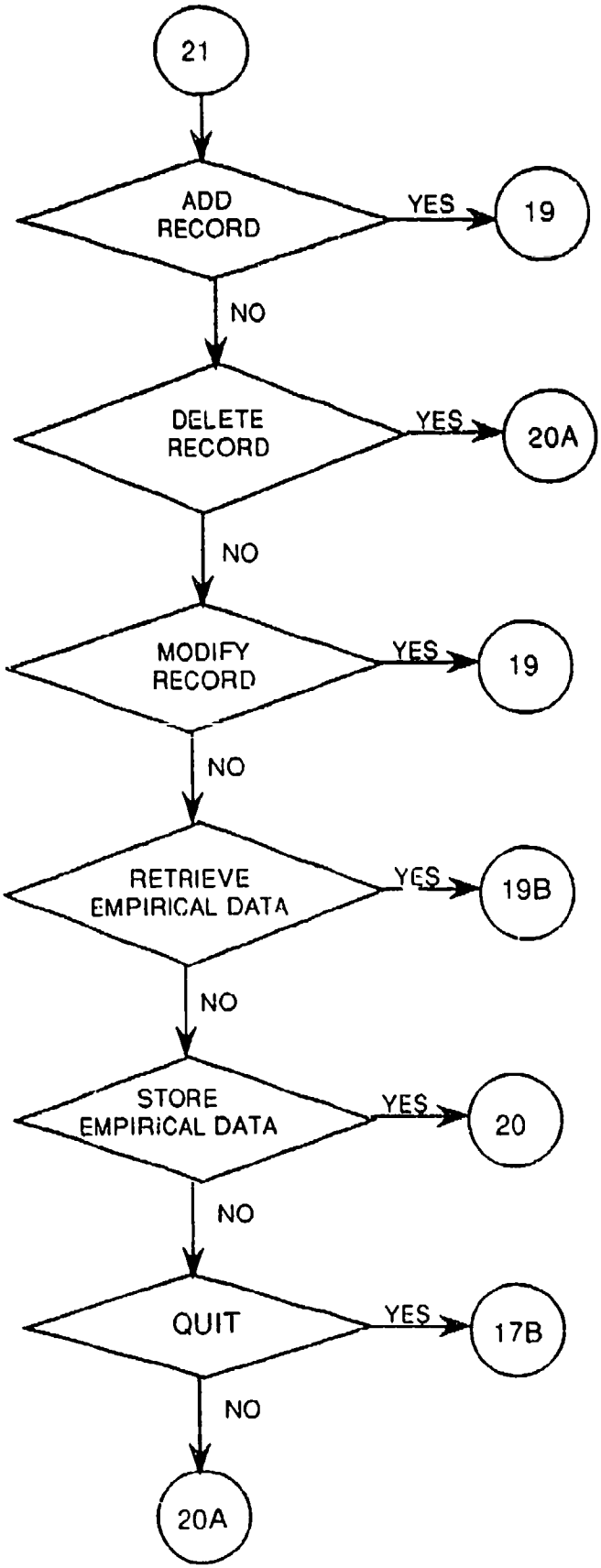


Purpose: To extract previously defined empirical data from file
Input: N/A
Output: Empirical data



Purpose: To store empirical data that are defined
Input: Empirical data
Output: N/A

Purpose: To display empirical data on screen
Input: Empirical data
Output: Screen display

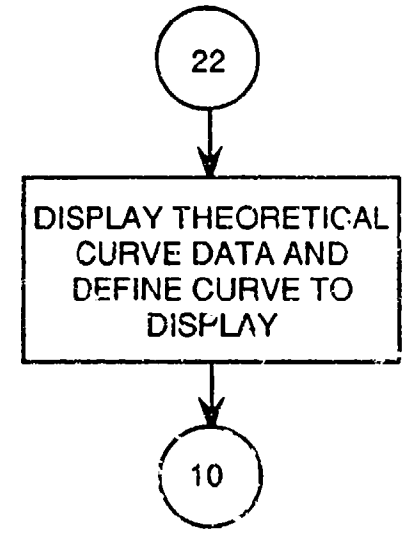


LAST ENTRY SET

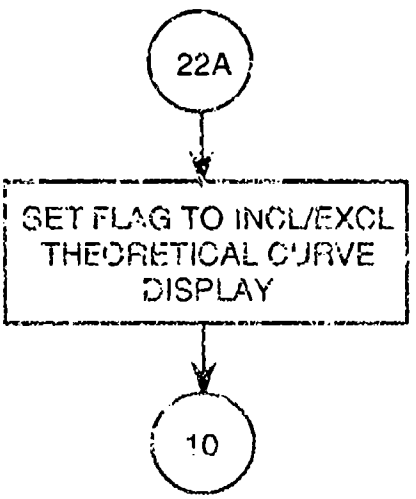
DELETES SPECIFIED RECORD

LAST ENTRY SET

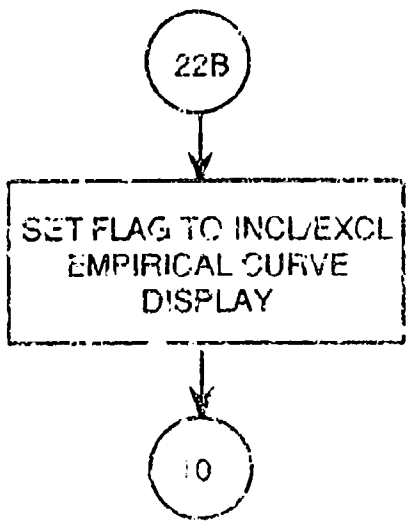
EDIT MODE SET



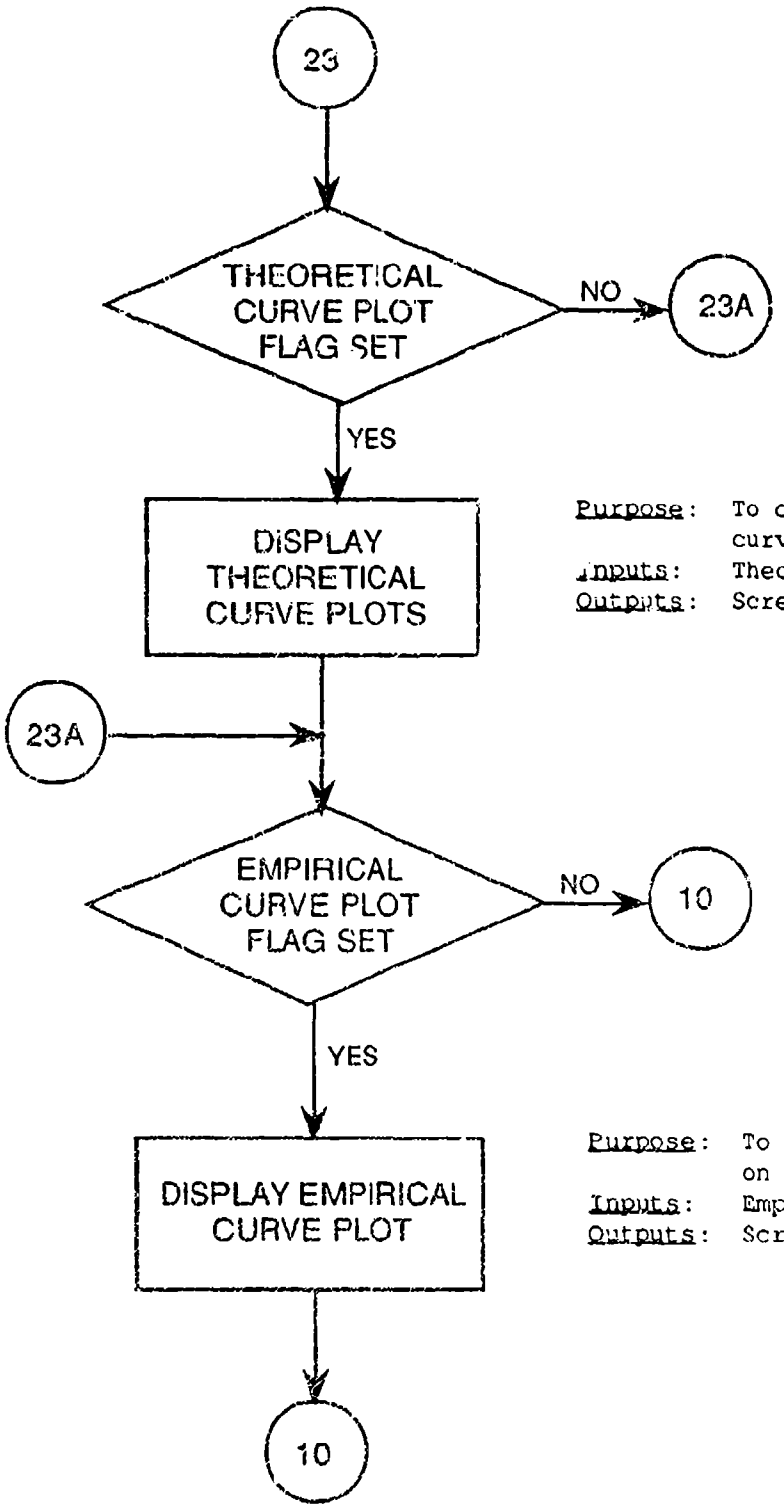
Purpose: To display theoretical curve data and menu of curves to be plotted
Input: Theoretical curve data
Output: Display screen, selected curve



Purpose: Determines whether to include/exclude theoretical curve displ
Input: Theoretical curve plot flag
Output: Theoretical curve plot flag



Purpose: Determines whether to include/exclude empirical curve display
Input: Empirical curve plot flag
Output: Empirical curve plot flag



Purpose: To display selected theoretical curves on screen
Inputs: Theoretical curve data
Outputs: Screen display

Purpose: To display empirical curve data on screen
Inputs: Empirical curve data
Outputs: Screen display

APPENDIX B

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM CODE

```
10        'AIMING ERROR MODEL VERSION 6.0 - EGA COLOR GRAPHICS (WITH MATH COPROCESSOR)
20        '6 JUNE 1987
30        'COMBINATION OF JOEL KALB'S AND SANDER REINHARTZ'S AIM ERROR PROGRAMS.
40        'AUTHORS = JEFFERY L. MAXEY, SR. & SANDER REINHARTZ
51        SCREEN 8
52        COLOR 15,1
60        OPTION BASE 1
62        DIM XPT(9), YPT(9), NXPTS(9), NYPTS(9), PLOTX(3,200), PLOTY(3,200), DAT(3,200)
63        DIM ADXPLT(30), ADYPLT(30), PLTXX(30), PLTYX(30), SIGMA1(3), C1(4), BLANK$(23)
64        DIM CNAME$(3,30), CVALUE(3,30), TFACTOR(3), TDUMMY(3), DNAME$(3,30), DVALUE(3,30)
71        RB = 250                                  ' IDENTIFY BATTLESIGHT RANGE
72        VW = 0                                    ' IDENTIFY CROSSDRIFT
73        VR = 0                                    ' IDENTIFY TARGET SPEED
74        PJ = 1                                    ' INITIALIZE PROJECTILE ID CODE
75        TTYPE$ = "  E Silhouette   "              ' IDENTIFY TARGET TYPE
76        RD$ = "M193"                              ' IDENTIFY ROUND TYPE
77        FLAG5 = 0
80        SIGMA = 1                                 ' INITIALIZE AIM ERROR FOR PERFORMANCE MODEL
81        TGTNO = 1                                 ' E-TYPE SILOUETTE CODE
82        AET = 0                                   ' TOTAL ESTIMATED AIM ERROR
83        SIGMA1(1) = 1                             ' INITIALIZE 1ST THEORETICAL CURVE AIM ERROR
84        SIGMA1(2) = 2                             ' INITIALIZE 2ND THEORETICAL CURVE AIM ERROR
85        SIGMA1(3) = 3                             ' INITIALIZE 3RD THEORETICAL CURVE AIM ERROR
86        SNO = 1
87        TCURVE$ = "Curve(s) 1,2,3"
88        ECURVE$ = "Not Defined"
89        CIX = 0
90        CIY = 0
91        CJX = 0
92        CJY = 0
99        B = 1                                     ' INITIALIZE TARGET HEIGHT
100       A = .486*B                                ' INITIALIZE TARGET WIDTH
110       N = INT(B)
111       IF N < 1 THEN N = 1
112       C = .256*B                                ' INITIALIZE TARGET HEAD HEIGHT
113       D = .211*B                                ' INITIALIZE TARGET HEAD WIDTH
114       GOSUB 11650                               ' REFRESH SCREEN
115       PRINT "                MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM" : PRINT " "
118       PRINT "                          DEVELOPED BY" : PRINT " "
119       PRINT "                JEFFREY MAXEY      SANDER REINHARTZ" : PRINT " "
120       PRINT "                              GENE CUCCARRESE" : PRINT " "
121       PRINT "              ADVANCED TECHNOLOGY, INC., ORLANDO, FL. 32803" : PRINT " "
122       PRINT "                       JOEL KALB     JIM TORRE" : PRINT " "
123       PRINT "                 U. S. ARMY HUMAN ENGINEERING LABORATORY" : PRINT " "
124       PRINT "                                  FOR" : PRINT " "
125       PRINT "        U. S. ARMY FM TRADE & U. S. ARMY HUMAN ENGINEERING LABORATORY" : PRINT " "
126       PRINT "                              (INITIALIZING)"
127       BLANK$(1) = " "
130       BLANK$(2) = "  "
131       BLANK$(3) = "   "
132       BLANK$(4) = "    "
133       BLANK$(5) = "     "
134       BLANK$(6) = "      "
135       BLANK$(7) = "       "
136       BLANK$(8) = "        "
```

```
137       BLANK$(9) = "         "
138       BLANK$(10) = "          "
139       BLANK$(11) = "           "
140       BLANK$(12) = "            "
141       BLANK$(13) = "             "
142       BLANK$(14) = "              "
143       BLANK$(15) = "               "
144       BLANK$(16) = "                "
145       BLANK$(17) = "                 "
146       BLANK$(18) = "                  "
147       BLANK$(19) = "                   "
148       BLANK$(20) = "                    "
149       BLANK$(21) = "                     "
150       BLANK$(22) = "                      "
151       BLANK$(23) = "                       "
152       ADDEC = 0                              ' INITIALIZE PLOT EMPIRICAL CURVE DATA
153       ADDTC = 1                              ' INITIALIZE PLOT THEORETICAL CURVE DATA
154       STSEC$ = "EXCLUDED"
155       STSTC$ = "INCLUDED"
156       GORND = 1
157       GM = 7
158       PSTA = 1
159       PEND = 3
160       FOR PM = 1 TO 3
161           GOSUB 15580
162       NEXT PM
163       PMT = 3
164       GOSUB 11650                            ' REFRESH SCREEN
165       '
170       ' DISPLAY MAIN MODEL MENU
180       '
190       PRINT "                 ------------------------------------------"
192       PRINT "                |                                          |"
193       PRINT "                |     Select Model Option                  |"
194       PRINT "                |                                          |"
200       PRINT "                |        Parameter Analysis ..... 1        |"
210       PRINT "                |        Graphic Analysis ....... 2        |"
220       PRINT "                |        Quit Model ............. 3        |"
221       PRINT "                |__________________________________________|"
222       PRINT " "
230       INPUT "                                  Enter --) ";GTYPE    ' IDENTIFY MODEL TYPE
240       IF GTYPE < 1 OR GTYPE > 3 THEN GOTO 153  ' ERROR CONDITION EXISTS
250       IF GTYPE = 2 THEN KEY OFF : GOTO 4270    ' PERFORM AIMING ERROR DATA ANALYSIS
260       IF GTYPE = 3 THEN GOTO 2410              ' EXIT MODEL
270       '
280       ' PERFORM AIMING ERROR MODEL
290       '
310       MAXXRES = 640      : MAXYRES = 200   ' SCREEN MAX RESOLUTION X & Y
320       ASPECTRATIO = 4/3                    ' SCREEN RATIO OF X TO Y
400       R = 250                              ' TARGET RANGE
420       PN = 1
450       PI = 3.141593                        ' CONSTANT VALUE FOR PIE
460       CIX = 0                              ' X ZERO AIM POINT
470       CIY = 0                              ' Y ZERO AIM POINT
480       CJX = 0                              ' X ADJUSTED ZERO AIM POINT
```

```
490       CCY = 0                               ' Y ADJUSTED ZERO AIM POINT
500       SIGMA = 1                             ' AIM ERROR OR STANDARD DEVIATION
510       TOL = .0001                           ' CONSTANT TOLERANCE VALUE
520       MAXCNT = 10
530       AREA = A*(B-C)+C*D                    ' AREA OF THE TARGET
540       RADCIR = SQR(AREA/PI)
550       GOSUB 2870                            ' ESTABLISH TRAJECTORY INFO
560       RS = R * SIGMA / 1000
565       GOSUB 3320                            ' ADJUST X & Y ZERO/ZERO POINTS
570       GOSUB 3730                            ' ESTABLISH HIT PROBABILITY
580       GOSUB 2500                            ' DISPLAY AIMING ERROR MODEL MENU ON SCREEN
590       IF CHOICE = 1 THEN GOSUB 730 : GOSUB 780 : GOSUB 870       ' IDENTIFY BATTLESIGHT RANGE & ROUND TYPE
600       IF CHOICE = 2 THEN GOSUB 940 : GOSUB 870                   ' IDENTIFY CROSSDRIFT SPEED
610       IF CHOICE = 3 THEN GOSUB 1090 : GOSUB 1250 : GOSUB 870     ' IDENTIFY TARGET CHARACTERISTICS
620       IF CHOICE = 4 THEN GOSUB 1430 : GOSUB 1540 : GOSUB 870     ' IDENTIFY TARGET RANGE / SPEED
630       IF CHOICE = 5 THEN GOSUB 1690                              ' COMPUTE AIM ERROR
640       IF CHOICE = 6 THEN GOTO 1930                               ' COMPUTE HIT PROBABILITY
650       IF CHOICE = 7 THEN GOSUB 2190 : GOSUB 870                  ' ESTABLISH ADJUSTMENT TO AIM IN X & Y
660       IF CHOICE = 8 THEN GOSUB 5240                              ' DRAW AIMING ERROR MODEL GRAPH
670       IF CHOICE = 9 THEN GOTO 71                                 ' RETURN TO MAIN MENU
680       IF CHOICE ( 1 OR CHOICE ) 9 THEN GOTO 580                 ' ERROR HANDLER
690       GOTO 580                                                   ' RETURN TO AIMING ERROR MODEL MENU
700       '
710       ' IDENTIFY BATTLESIGHT RANGE AND ROUND TYPE
720       '
730          GOSUB 11650                        ' REFRESH SCREEN
731          A$ =         "\                                       \&\              \"
732          PRINT        "           ____________________________________________"
733          PRINT        "          |                                            |"
740          PRINT USING A$:"        |   Current Projectile Type ":RD$:"            |"
749          PRINT        "          |                                            |"
750          PRINT        "          |        M193 Projectile ...............  1   |"
752          PRINT        "          |        M855 Projectile ...............  2   |"
753          PRINT        "          |        AT-4 Projectile ...............  3   |"
754          PRINT        "          |                                            |"
755          PRINT        "          |   Enter (cr) To Keep Current Projectile Type |"
756          PRINT        "          |                                            |"
757          PRINT        "          |   Or Enter New Projectile Type             |"
758          PRINT        "          |____________________________________________|"
759          PRINT " "
763          INPUT        "                            Enter --) ":A$
764          IF A$ = "" THEN GOTO 767
765          IF VAL(A$) ( 1 OR VAL(A$) ) 3 THEN GOTO 730
766          PJ = VAL(A$)
767          IF PJ = 1 THEN RD$ = "M193"
768          IF PJ = 2 THEN RD$ = "M855"
769          IF PJ = 3 THEN RD$ = "AT-4"
776        RETURN
780          GOSUB 11650                        ' REFRESH SCREEN
781          BR = RB                            ' SAVE OLD CURRENT BATTLESIGHT RANGE
782          A$ =         "\                                       \###\        \"
783          PRINT        "           ___________________________________________"
784          PRINT        "          |                                           |"
790          PRINT USING A$:"        |       Current Battlesight Range ":RB:" m   |"
800          PRINT        "          |                                           |"
```

```
801         PRINT "                    |          Enter (cr) To Keep Current Value       |"
802         PRINT "                    |                                                 |"
810         PRINT "                    |          Or Enter New Battlesight Range         |"
820         PRINT "                    |_________________________________________________|"
821         PRINT " "
830         INPUT "                                        Enter --) ";A$
840         IF A$ = "" THEN GOTO 860
850         RB = VAL(A$)
860         IF TGTNO <= 2 AND (RB < 1 OR RB > 400) THEN RB = BR : GOTO 780
865         IF TGTNO > 2 AND (RB < 1 OR RB > 4000) THEN RB = BR : GOTO 780
866       RETURN
867       '
868       ' ESTABLISH BALLISTICS, AIM, AND HIT PROBABILITY
869       '
870         GOSUB 2870                  ' ESTABLISH TRAJECTORY INFO
880         GOSUB 3320                  ' ADJUST X & Y ZERO/ZERO POINTS
890         GOSUB 3730                  ' ESTABLISH HIT PROBABILITY
900       RETURN
910       '
920       ' IDENTIFY CROSSDRIFT SPEED
930       '
940         GOSUB 11650                 ' REFRESH SCREEN
941         A$ =          "\                                    \##.##\           \"
942         PRINT "                    |_________________________________________________|"
943         PRINT "                    |                                                 |"
950         PRINT USING A$;"           |    Current Crossdrift Speed ";VW;" m/s          |"
960         PRINT "                    |                                                 |"
961         PRINT "                    |    Enter (cr) To Keep Current Value             |"
962         PRINT "                    |                                                 |"
970         PRINT "                    |    Or Enter New Crossdrift Speed (+ or -)       |"
980         PRINT "                    |_________________________________________________|"
981         PRINT " "
990         INPUT "                                        Enter --) ";A$
1000        IF A$ = "" THEN GOTO 1020
1010        VW = VAL(A$)
1020      RETURN
1060      '
1070      ' IDENTIFY TARGET CHARACTERISTICS
1080      '
1090        GOSUB 11650                 ' REFRESH SCREEN
1091        A$ =          "\                                \&\          \"
1092        PRINT "                    |_________________________________________________|"
1093        PRINT "                    |                                                 |"
1100        PRINT USING A$;"           |      Current Target Type ";TTYPE$;"          |"
1110        PRINT "                    |                                                 |"
1140        PRINT "                    |          E Type Silhouette ..... 1              |"
1150        PRINT "                    |          F Type Silhouette ..... 2              |"
1160        PRINT "                    |          Tank - Side View ...... 3              |"
1170        PRINT "                    |          Tank - Front View ..... 4              |"
1180        PRINT "                    |                                                 |"
1181        PRINT "                    |      Enter (cr) To Keep Current Target Type     |"
1182        PRINT "                    |                                                 |"
1183        PRINT "                    |      Or Enter New Target Type                   |"
1190        PRINT "                    |_________________________________________________|"
1191        PRINT " "
```

```
1192      INPUT       "                                  Enter --) ":A$
1200      IF A$ = "" THEN GOTO 1203
1201      IF VAL(A$) ( 1 OR VAL(A$) ) 4 THEN GOTO 1050
1202      TGTNO = VAL(A$)
1203      IF TGTNO = 1 THEN TTYPE$ = "  E Silhouette  "
1205      IF TGTNO = 2 THEN TTYPE$ = "  F Silhouette  "
1206      IF TGTNO = 3 THEN TTYPE$ = " Tank - Side View"
1207      IF TGTNO = 4 THEN TTYPE$ = "Tank - Front View"
1245   RETURN
1250      GOSUB 11650                       ' REFRESH SCREEN
1251      A$ =        "\                                    \##.##\            \"
1252      PRINT       "           ________________________________________"
1253      PRINT       "          |                                        |"
1260      PRINT USING A$:"|   Current Target Height ":B:" m              |"
1270      PRINT       "          |                                        |"
1271      PRINT       "          |   Enter (cr) To Keep Current Value     |"
1272      PRINT       "          |                                        |"
1280      PRINT       "          |   Or Enter New Target Height (1-10 m)  |"
1290      PRINT       "          |________________________________________|"
1291      PRINT " "
1300      INPUT       "                                  Enter --) ":A$
1310      IF A$ = "" THEN 1330
1320      HT = VAL(A$)
1321      IF HT ( 1 OR HT ) 10 THEN GOTO 1250
1322      B = HT
1330      IF TGTNO = 1 THEN A = .486*B : C = .256*B : D = .211*B
1340      IF TGTNO = 2 THEN A = 1.344*B : C = .5625*B : D = .4375*B
1350      IF TGTNO = 3 THEN A = 2.69*B : C = .359*B : D = .641*B
1360      IF TGTNO = 4 THEN A = 1.206*B : C = .3*B : D = .49*B
1361      IF GTYPE = 2 THEN RETURN
1370      N = INT(B)
1380      IF N ( 1 THEN N = 1
1420   RETURN
1421   '
1422   ' DEFINE TARGET RANGE
1423   '
1430      GOSUB 11650                       ' REFRESH SCREEN
1431      BR = R                            ' SAVE OLD CURRENT RANGE
1432      A$ =        "\                                    \###.##\          \"
1433      PRINT       "           ________________________________________"
1434      PRINT       "          |                                        |"
1440      PRINT USING A$:"|   Current Target Range ":R:" m               |"
1450      PRINT       "          |                                        |"
1451      PRINT       "          |   Enter (cr) To Keep Current Value     |"
1452      PRINT       "          |                                        |"
1460      PRINT       "          |   Or Enter New Target Range            |"
1470      PRINT       "          |________________________________________|"
1471      PRINT " "
1480      INPUT       "                                  Enter --) ":A$
1490      IF A$ = "" THEN GOTO 1510
1500      R = VAL(A$)
1510      IF TGTNO (= 2 AND (R ( 1 OR R ) 400) THEN R = BR : GOTO 1430
1520      IF TGTNO ) 2 AND (R ( 1 OR R ) 4000) THEN R = BR : GOTO 1430
1530      RS = R * SIGMA/1000
1535   RETURN
```

```
1536      '
1537      ' DEFINE TARGET SPEED
1538      '
1540          GOSUB 11650                         ' REFRESH SCREEN
1541          A$ =          "\                                  :##.##\           \"
1542          PRINT         "                    _____________________________________"
1543          PRINT         "                   |                                     "
1550          PRINT USING A$;"                  |     Current Target Speed ":VR:" m/s  :"
1560          PRINT         "                   |                                     |"
1561          PRINT         "                   |     Enter (cr) To Keep Current Value:"
1562          PRINT         "                   |                                     :"
1570          PRINT         "                   |     Or Enter New Target Speed (+ or -):
1580          PRINT         "                   |_____________________________________|"
1581          PRINT " "
1590          INPUT         "                                  Enter --) ":A$
1600          IF A$ = "" THEN GOTO 1650
1610          VR = VAL(A$)
1650      RETURN
1660      '
1670      ' AIM ERROR ANALYSIS
1680      '
1690          TAEID = 0                           ' INITIALIZE MANNER OF COMPUTING AIM ERROR
1691          OLDSIGM = SIGMA : OLDPROB = PROB
1692          PM = 1
1693          GOSUB 15770                         ' DETERMINE MANNER IN WHICH AIM ERROR IS TO BE COMPUTED
1694          FLAG3 = 0
1700          IF TAEID ) 1 THEN GOTO 1803
1701          GOSUB 11650                               ' REFRESH SCREEN
1702          A$ =          "\                                  \###.##\           \"
1710          PRINT         "                    _____________________________________"
1720          PRINT         "                   |                                     |"
1730          PRINT USING A$;"                  |    Current Aim Error ":SIGMA:" mils      :"
1740          PRINT         "                   |                                     |"
1750          PRINT         "                   |    Enter (cr) To Keep Current Value |"
1760          PRINT         "                   |                                     |"
1770          PRINT         "                   |    Or Enter New Aim Error           |"
1780          PRINT         "                   |_____________________________________|"
1790          PRINT " "
1800          INPUT         "                                  Enter --) ":A$
1801          IF A$ = "  "HEN FLAG3 = 0 : GOTO 1820
1802          SIGMA = VA (A$)
1803          IF SIGMA = 0 THEN SIGMA = .00001
1804          FLAG3 = 1
1805          SGUESS2 = SIGMA
1820          RS = R * SIGMA / 1000
1830          GOSUB 3730                          ' ESTABLISH HIT PROBABILITY
1831          NEWSIGM = SIGMA : NEWPROB = PROB
1832          GOSUB 9690
1840      RETURN
1900      '
1910      ' DEFINE HIT PROBABILITY
1920      '
1930      GOSUB 11650                       ' REFRESH SCREEN
1931      A$ =          "\                                        \#.##\           \"
1932      B$ =          "\                                    \###.##\           \"
```

```
1933    PRINT           "                    ___________________________________________"
1934    PRINT           "                   |                                           |"
1940    PRINT USING A$;"                   |     Current Hit Probability ";PROB:"        |"
1950    PRINT           "                   |                                           |"
1960    PRINT USING B$;"                   |     Current Aim Error ";SIGMA:" mils        |"
1980    PRINT           "                   |                                           |"
1990    PRINT           "                   |     Enter (cr) To Keep Current Values     |"
1991    PRINT           "                   |                                           |"
1992    PRINT           "                   |     Or Enter New Hit Probability (0-1)    |"
2000    PRINT           "                   |___________________________________________|"
2001    PRINT " "
2010    INPUT           "                                   Enter --> ";A$
2020    IF A$ = "" THEN FLAG4 = 0 : USERPHIT = 0 : PHIT = PROB : GOTO 2040
2030    PHIT = VAL(A$)
2031    USERPHIT = PHIT
2032    FLAG4 = 1
2040    IF PHIT <= 0 THEN PHIT = .00001        ' DEFINE LOWER LIMIT OF HIT PROBABILITY
2050    IF PHIT >= 1 THEN PHIT = 1-.00001      ' DEFINE UPPER LIMIT OF HIT PROBABILITY
2051    OLDPROB = PROB : OLDSIGM = SIGMA
2060    GOSUB 3380                             ' ESTABLISH THE INVERSE HIT PROBABILITY
2061    IF FLAG5 = 1 THEN FLAG5 = 0 : GOTO 1930
2062    IF FLAG5 = 2 THEN FLAG5 = 0 : GOTO 580
2070    NEWSIGM = SIGMA
2080    GOSUB 3730                             ' ESTABLISH HIT PROBABILITY
2081    NEWPROB = PROB
2082    GOSUB 9490
2090    GOTO 580
2160    '
2170    ' DEFINE X AIM POINT ADJUSTMENT
2180    '
2190        GOSUB 11650                            ' REFRESH SCREEN
2191        A$ =          "\                                        \##.##\          \"
2200        PRINT         "                    ___________________________________________"
2201        PRINT         "                   |                                           |"
2202        PRINT USING A$;"                   |     Current X-Aim Adjustment ";CJX;" m     |"
2203        PRINT         "                   |                                           |"
2204        PRINT         "                   |     Enter (cr) To Keep Current Value      |"
2205        PRINT         "                   |                                           |"
2213        PRINT         "                   |     Or Enter New X-Aim Adjustment (+ or -)|"
2214        PRINT         "                   |___________________________________________|"
2215        PRINT " "
2216        INPUT         "                                   Enter --> ";A$
2250        IF A$ = "" THEN GOTO 2265
2260        CJX = VAL(A$)
2265        IF GTYPE = 2 THEN GOTO 2370
2266    '
2267    ' DEFINE Y AIM POINT ADJUSTMENT
2268    '
2270        GOSUB 11650                            ' REFRESH SCREEN
2271        A$ =          "\                                        \##.##\          \"
2272        PRINT         "                    ___________________________________________"
2273        PRINT         "                   |                                           |"
2280        PRINT USING A$;"                   |     Current Y-Aim Adjustment ";CJY;" m     |"
2290        PRINT         "                   |                                           |"
2291        PRINT         "                   |     Enter (cr) To Keep Current Value      |"
```

```
2292          PRINT          "              |                                          |"
2300          PRINT          "              |    Or Enter New Y-Aim Adjustment (+ or -)    |"
2310          PRINT          "              |__________________________________________|"
2311          PRINT " "
2320          INPUT          "                                    Enter --) ";A$
2330          IF A$ = "" THEN GOTO 2370
2340          CJY = VAL(A$)
2370      RETURN
2380      '
2390      ' EXIT MODEL
2400      '
2410      SYSTEM
2460      END
2470      '
2480      ' PARAMETER ANALYSIS MENU
2490      '
2500          CLS
2510          PRINT "                              PARAMETER ANALYSIS"
2520          PRINT "-------------------------------------------------------------------------------"
2530          A$ =          "\                    \&\                          \&"
2540          B$ =          "\                   \###.##\    \"
2550          C$ =          "\                   \###.##\                  \"
2560          D$ =          "\                   \###.##\                        \##.##\  \"
2570          E$ =          "\                   \###.##\                      \####.##\    \"
2580          F$ =          "\                   \###.##\                        \##.##\  \"
2585          G$ =          "\                  \####.##\                       \###.##\   \"
2590          PRINT USING A$;" Projectile Type     ";RD$;"              Target Type";TTYPE$
2600          PRINT USING B$;" Initial Pitch Angle ";GAMMA*1000;" mils"
2610          PRINT USING C$;" Flight Time         ";TOF;" s             Target"
2620          PRINT USING D$;" Impact Velocity     ";VEL;" m/s           Dimensions    Height ";B;" m"
2630          PRINT USING D$;" X - Impact Point    ";CIX;" m                           Width  ";A;" m"
2640          PRINT USING E$;" Y - Impact Point    ";CIY;" m                           Area";(A*(B-C)+(C*D));" m^2"
2650          PRINT " "
2660          PRINT " Battlefield Conditions"
2670          PRINT "-------------------------------------------------------------------------------"
2680          PRINT USING F$;" Battlesight         ";RB;" m             X - Aim Adjustment   ";CJX;" m"
2690          PRINT USING F$;" Crossdrift          ";VW;" m/s           Y - Aim Adjustment   ";CJY;" m"
2700          PRINT USING G$;" Target Range        ";R;" m             Aim Error            ";SIGMA;" mils"
2710          PRINT USING F$;" Target Speed        ";VR;" m/s           Hit Probability      ";PROB
2720          PRINT " "
2730          PRINT " Select Function(s)"
2740          PRINT "-------------------------------------------------------------------------------"
2750          PRINT " 1 - Projectile Type/Battlesight   4 - Target Range/Speed   7 - Adjust X/Y Aim"
2760          PRINT " 2 - Crossdrift Speed              5 - Aim Error           8 - Graph Results"
2770          PRINT " 3 - Target Characteristics        6 - Hit Probability     9 - Quit"
2801          PRINT "-------------------------------------------------------------------------------"
2810          INPUT "                              Enter --) ";CHOICE
2830      RETURN
2840      '
2850      ' SET TRAJECTORY CHARACTERISTICS OF ROUND TYPE
2860      '
2870          IF PJ = 1 THEN GOSUB 2930
2871          IF PJ = 2 THEN GOSUB 3070
2872          IF PJ = 3 THEN GOSUB 3111
2880          GOSUB 3210
```

```
2890        RETURN
2900        '
2910        ' DEFINE M193 ROUND CHARACTERISTIC DATA
2920        '
2930            C1(1) =    .00000516432395#
2950            C1(2) =    5.54991899D-09
2960            C1(3) =   -2.56942567D-12
2970            C1(4) =     .54311494D-14
2980            RINF  = 1139.4    'MAX RANGE
2990            VO = 989.61        'UPDATED 6/9/87
3000            TOFI = 1404.55     'UPDATED 6/9/87
3010            VEL1 = 1058.5      'UPDATED 6/9/87
3020            VEL2 = 1837.6      'UPDATED 6/9/87
3030        RETURN
3040        '
3050        ' DEFINE M855 ROUND CHARACTERISTIC DATA
3060        '
3070            C1(1) =    .00000536026011#
3090            C1(2) =    4.06575955D-09
3100            C1(3) =    1.87280127D-13
3101            C1(4) =    5.73649176D-15
3102            RINF  = 1464.87   'MAX RANGE
3103            VO = 924.57        'UPDATED 6/9/87
3104            TOFI = 1767.26     'UPDATED 6/9/87
3105            VEL1 = 1319.82     'UPDATED 6/9/87
3106            VEL2 = 2641.74     'UPDATED 6/9/87
3107        RETURN
3108        '
3109        ' DEFINE AT-4 ROUND CHARACTERISTIC DATA
3110        '
3111            C1(1) =   5.087435E-5
3113            C1(2) =   3.260888E-8
3114            C1(3) =   1.064895E-11
3115            C1(4) =   2.072329E-14
3116            RINF  = 1881.74   'MAX RANGE
3117            VO = 290.6         'METERS PER SECOND
3118            TOFI = 2395.6      'UPDATED 6/9/87
3119            VEL1 = 3946.4      'UPDATED 6/9/87
3120            VEL2 = 1296.9      'UPDATED 6/9/87
3121        RETURN
3180        '
3190        ' COMPUTE TRAJECTORY DATA
3200        '
3210            GAMMA = RB * (C1(1) + RB * (C1(2) + RB * (C1(3) + RB * C1(4))))
3220            YTRAJ = GAMMA * R * (1 - R / RB) / (1 - R / RINF)
3230            TOF = R / (VO * (1 - R / TOFI))                          'UPDATED 6/9/87
3240            XTRAJ = VW*(R/1215.36)^2/(1-(R/1045.41)+(R/1770.05)^2)
3250            VEL = VO * (1 - R / VEL1) / (1 + R / VEL2)               'UPDATED 6/9/87
3260            XO = VR * TOF
3270            YO = 0
3280        RETURN
3290        '
3300        ' SET X & Y IMPACT POINT
3310        '
3320            CIX = CJX + (XTRAJ - XO) * N
```

```
3330          CIY = CJY + (YTRAJ - YC) * S
3340      RETURN
3350      '
3360      ' DEVELOPMENT OF INVERSE PROBABILITY DATA
3370      '
3380          FLAG3 = 0
3390          RSTEMP = RS
3400          RS = RADCIR / SQR(-2 * LOG(1 - PHIT))
3410          SGUESS = RS * 1000 / R
3411          NEWSIGM = SGUESS
3420          GOSUB 11650                    ' REFREEH SCREEN
3421          A$ =          "\                                    \####.##\          \"
3422          PRINT         "                                                          "
3423          PRINT         "          ------------------------------------------------"
3424          PRINT USING A$;"          |                                               |"
3425          PRINT         "          |      First Aim Error Estimate ";SGUESS;" mils    |"
3433          PRINT         "          |                                               |"
3434          PRINT         "          |      Enter (cr) To Keep First Estimate        |"
3435          PRINT         "          |                                               |"
3436          PRINT         "          |      Or Enter User Estimate (in mils)         |"
3437          PRINT " "                 |_______________________________________________|"
3440          INPUT         "                                Enter --) ",A$
3450          IF A$ = "" THEN GOTO 3520
3460          SGUESS2 = VAL(A$)
3500          RS = SGUESS2 * R / 1000
3501          FLAG3 = 1
3510          GOTO 3530
3520          SGUESS2 = 0
3521          RS = SGUESS * R / 1000
3530          COUNT = 0
3540          FLAG1 = 0
3550          FLAG2 = 0
3560          WHILE FLAG1 = 0 AND FLAG2 = 0
3570              GOSUB 3730                 ' ESTABLISH HIT PROBABILITY
3580              TERM1 = (X1 * E1 - X2 * E2) * (H1 - H2) + (Y1 * G1 - Y2 * G2) * (F1 - F2)
3590              TERM2 = (X3 * E3 - X4 * E4) * (H3 - H4) + (Y3 * G3 - Y4 * G4) * (F3 - F4)
3600              PROBDERIV = -(TERM1 + TERM2) / RS
3610              IF PROBDERIV = 0 THEN GOTO 10150
3620              CORR = (PROB - PHIT) / PROBDERIV
3630              RS = RS - CORR
3640              COUNT = COUNT + 1
3650              IF ABS(CORR) < TOL * ABS(RS) THEN FLAG1 = 1
3660              IF COUNT > MAXCNT THEN FLAG2 = 1
3670          WEND
3680          IF FLAG2 = 1 OR RS < 0 THEN GOTO 10020 ELSE SIGMA = RS * 1000 / R
3690      RETURN
3700      '
3710      ' DEFINE HIT PROBABILITY BASED ON TARGET SIZE
3720      '
3730          X1 = (A/2 - CIX) / RS
3740          X2 = (-A/2 - CIX) / RS
3750          X3 = (D/2 - CIX) / RS
3760          X4 = (-D/2 - CIX) / RS
3770          Y1 = (B/2 - C - CIY) / RS
3780          Y2 = (-B/2 - CIY) / RS
```

```
3790          Y3 = (D/2 - CY) / RS
3800          Y4 = Y1
3810          X = X1
3820          GOSUB 4140
3830          E1 = Z
3840          F1 = P
3850          X = X2
3860          GOSUB 4140
3870          E2 = Z
3880          F2 = P
3890          X = X3
3900          GOSUB 4140
3910          E3 = Z
3920          F3 = P
3930          X = X4
3940          GOSUB 4140
3950          E4 = Z
3960          F4 = P
3970          X = Y1
3980          GOSUB 4140
3990          G1 = Z
4000          H1 = P
4010          X = Y2
4020          GOSUB 4140
4030          G2 = Z
4040          H2 = P
4050          X = Y3
4060          GOSUB 4140
4070          G3 = Z
4080          H3 = P
4090          G4 = G1
4100          H4 = H1
4110          PROB = (F1-F2)*(H1-H2)+(F3-F4)*(H3-H4)
4120        RETURN
4130        '
4131        ' GAUSS
4132        '
4140          XA = ABS(X)
4150          IF XA > 10 THEN XA = 10
4160          A1 = .4361836
4170          A2 = -.1201676
4180          A3 = .937298
4190          T = 1 / (1 + .33267 * XA)
4200          Z = .3989423 * EXP(-.5 * XA * XA)
4210          P = 1 - Z * (T * (A1 + T * (A2 + T * A3)))
4220          IF X < 0 THEN P = 1 - P
4230        RETURN
4240      '
4250      ' PROCESS THE GRAPHIC ANALYSIS MODEL
4260      '
4270        GOSUB 11650                          ' REFRESH SCREEN
4280        COLOR 15
4290      '
4300      ' DISPLAY GRAPHIC ANALYSIS MENU
4310      '
```

```
4317      IF PLOTPT = 0 THEN ECURVE$ = "Not Defined"
4318      C$ =          "\                                    \&\                    \"
4319      B$ =          "\                                          \&\          \"
4320      A$ =          "\                                             \&\         \"
4321      PRINT         "
4322      PRINT         "          |                                                  |"
4323      PRINT         "          |  Select Function                                 |"
4324      PRINT         "          |                                                  |"
4325      PRINT         "          |       Define Data                                |"
4424      PRINT         "          |          Theoretical ..................... 1    |"
4425      PRINT USING C$;"          |          Empirical ....."";ECURVE$;"..... 2    |"
4426      PRINT         "          |       Plot Curve(s)                              |"
4427      PRINT USING B$;"          |          Select Theoretical Curve(s) .."";TCURVE$;".. 3   |"
4428      PRINT USING A$;"          |          Include/Exclude Theoretical ....."";STSTC$;"..... 4   |"
4429      PRINT USING A$;"          |          Include/Exclude Empirical ......."";STSEC$;"..... 5   |"
4430      PRINT         "          |          Display ......................... 6    |"
4432      PRINT         "          |       Quit ............................... 7    |"
4433      PRINT         "          |__________________________________________________|"
4434      PRINT " "
4435      INPUT         "                                        Enter --) ";FC
4436      IF FC ( 1 OR FC ) 8 GOTO 4270
4437      IF FC = 1 THEN GOSUB 17930                ' DISPLAY THEORETICAL FUNCTION CODE MENU
4438      IF FC = 2 THEN GOSUB 18280                ' DISPLAY EMPIRICAL FUNCTION CODE MENU
4439      IF FC = 3 THEN GOSUB 18560                ' DEFINE CURVES TO BE PLOTTED
4440      IF FC = 4 THEN GOSUB 15175                ' INCLUDE/EXCLUDE INITIATION SWITCH
4441      IF FC = 5 THEN GOSUB 15160                ' INCLUDE/EXCLUDE INITIATION SWITCH
4442      IF FC = 6 THEN GOSUB 18231                ' DISPLAY GRAPHICS
4443      IF FC = 7 THEN GOTO 71                    ' RETURN TO MAIN MENU
4444      GOTO 4270
5210  '
5220  ' SET MAX/MIN RANGE OF TARGET
5230  '
5240          XPT(1) = ((A/2)/N)*64: YPT(1) = ((B/2-C)/N)*60
5250          XPT(2) = ((D/2)/N)*64: YPT(2) = ((B/2-C)/N)*60
5260          XPT(3) = ((D/2)/N)*64: YPT(3) = ((B/2)/N)*60
5270          XPT(4) = ((-D/2)/N)*64: YPT(4) = ((B/2)/N)*60
5280          XPT(5) = ((-D/2)/N)*64: YPT(5) = ((B/2-C)/N)*60
5290          XPT(6) = ((-A/2)/N)*64: YPT(6) = ((B/2-C)/N)*60
5300          XPT(7) = ((-A/2)/N)*64: YPT(7) = ((-B/2)/N)*60
5310          XPT(8) = ((A/2)/N)*64: YPT(8) = ((-B/2)/N)*60
5320          XPT(9) = ((A/2)/N)*64: YPT(9) = ((B/2-C)/N)*60
5330          GOSUB 5690              ' SET SCALE VALUE
5340          GOSUB 5610              ' SCALE MAX AND MIN VALUES
5350          GOSUB 5830              ' SET TRANSLATION VALUE OF TARGET
5360          GOSUB 5750              ' TRANSLATE MAX AND MIN VALUES
5370          GOSUB 5890              ' ADJUST MAX AND MIN VALUES TO SCREEN COORDINATES
5380          COLOR 15                ' SET FOREGROUND COLOR TO WHITE
5400          KEY OFF
5410          CLS
5420          CALL XYLABEL (N)        ' DISPLAY X & Y CARTESIAN GRAPH LABELS
5520          GOSUB 10890             ' DRAW 2 DIMENSION GRAPH
5530          GOSUB 6290              ' DRAW TARGET WITHIN GRAPH
5540          GOSUB 9240              ' SET RADIUS OF 40,86,99 % CIRCLES
5550          GOSUB 9310              ' DRAW CIRCLES AND DISPLAY SUPPORT DOCUMENTATION
5560          A$ = INKEY$ : IF A$ = "" GOTO 5560
```

```
5570        RETURN
5580        '
5590        ' SCALE POINTS OF TARGET
5600        '
5610            FOR PTNO = 1 TO 9
5620                NXPTS(PTNO) = XPT(PTNO) * XSCALE
5630                NYPTS(PTNO) = YPT(PTNO) * YSCALE
5640            NEXT PTNO
5650        RETURN
5660        '
5670        ' SET SCALING VALUE
5680        '
5690            XSCALE = 1
5700            YSCALE = XSCALE
5710        RETURN
5720        '
5730        ' TRANSLATION OF TARGET
5740        '
5750            FOR PTNO = 1 TO 9
5760                NXPTS(PTNO) = NXPTS(PTNO) + XTRANS
5770                NYPTS(PTNO) = NYPTS(PTNO) + YTRANS
5780            NEXT PTNO
5790        RETURN
5800        '
5810        ' SET TRANSLATION VALUE
5820        '
5830            XTRANS = 6
5840            YTRANS = 0
5850        RETURN
5860        '
5870        ' ADJUST FOR DOT WIDTH AND CONVERT TO SCREEN COORDINATE SYSTEM
5880        '
5890            FOR PTNO = 1 TO 9
5900                NXPTS(PTNO) =MAXXRES/2+NXPTS(PTNO)*(MAXXRES/MAXYRES/ASPECTRATIO)
5910                NYPTS(PTNO) =MAXYRES/2-NYPTS(PTNO)
5920            NEXT PTNO
5930        RETURN
6260        '
6270        ' DRAW REQUIRED TARGET ONTO SCREEN
6280        '
6290            DRAW "BM="+VARPTR$(NXPTS(1))+","+VARPTR$(NYPTS(1))
6300            FOR I = 2 TO 9
6310                DRAW "M="+VARPTR$(NXPTS(I))+","+VARPTR$(NYPTS(I))
6320            NEXT I
6330        RETURN
9210        '
9220        ' SCALE CIRCLE RADIUS VALUES
9230        '
9240            RAD1 = R * .132          ' UPDATE CIRCLE RADIUS VALUE 7/27/87
9250            RAD2 = R * .136          ' UPDATE CIRCLE RADIUS VALUE 7/27/87
9260            RAD3 = R * .14           ' UPDATE CIRCLE RADIUS VALUE 7/27/87
9270        RETURN
9280        '
9290        ' DRAW 40,86,99% CIRCLES, AIM POINT, AND SUPPORT DOCUMENTATION ONTO SCREEN
9300        '
```

```
9310        CKX = CIX/N
9311        CKY = CIY/N
9312        XPLT = (320 + (3 * (XTRANS - 1)) + (CKX * 150)
9313        YPLT = 100 - CKY * 60
9314        DRAW "BM="+VARPTR$(XPLT)+",="+VARPTR$(YPLT)    ' SET CURSOR TO START POINT
9315        DRAW "NU 3 ND 3 NL 5 NR 5"
9316        DRAW "BM 610,180"
9317        DRAW "U 6 R 2 H 2 G 2 R 2"
9318        DRAW "BM 540 180"
9319        DRAW "L 12 U 2 G 2 F 2 U 2"
9322        COLOR 2
9330        CIRCLE (320+(3*(XTRANS-1)+(CKX*150)),100-CKY*60),1*SIGMA/N*RAD1  ' UPDATED 7/27/87
9331        COLOR 4
9340        CIRCLE (320+(3*(XTRANS-1)+(CKX*150)),100-CKY*60),2*SIGMA/N*RAD2  ' UPDATED 7/27/87
9341        COLOR 14
9350        CIRCLE (320+(3*(XTRANS-1)+(CKX*150)),100-CKY*60),3*SIGMA/N*RAD3  ' UPDATED 7/27/87
9353        COLOR 15
9365        L$ = "\         \#.##\          \###.##.                    \###.##\  \"
9381        LOCATE 23,70
9382        PRINT "Meters"
9390        LOCATE 4,12
9400        PRINT USING L$;"Hit Prob =";PROB;"  Aim Error =";SIGMA;" mils  Target Range = ";D;" m"
9410        LOCATE 6,22
9420        PRINT "40, 86, And 99 Percent Round Impact Circles"
9430        LOCATE 23,25
9440        PRINT "Hit Any Key To Return To Main Menu"
9450    RETURN
9460    '
9470    ' DISPLAY ESTIMATION SUMMARY FOR HIT PROBABILITY
9480    '
9490        GOSUB 11650                              ' REFRESH SCREEN
9491        A$ =                                       "\                    \#.##          ##.##       \"
9492        B$ =                                       "\                    \#.##\
9493        D$ =                                       "\                       \          ###.##'      \"
9510        PRINT                                      "
9510        PRINT                                      "
9520        PRINT                                      "
9530        PRINT                                      "
9531        PRINT                                      "
9532        PRINT                                      "
9540        PRINT                                      "
9550        PRINT                                      "
9560        PRINT                                      "
9565        PRINT                                      "
9570        PRINT USING A$;                            "
9571        IF FLAG3 = 0 AND FLAG4 = 0 THEN GOTO 9583
9580        IF FLAG3 = 1 AND FLAG4 = 1 THEN PRINT USING A$;"
9581        IF FLAG3 = 1 AND FLAG4 = 0 THEN PRINT USING D$;"
9582        IF FLAG3 = 0 AND FLAG4 = 1 THEN PRINT USING B$;"
9590        PRINT USING D$;                            "
9600        PRINT USING A$;                            "
9610        PRINT                                      "
9620        PRINT " "
9630        PRINT                                      "
9640        A$ = INKEY$ : IF A$ = "" THEN GOTO 9640
```

```
|                                                                  |
|                    ESTIMATION SUMMARY                            |
|                    ------------------                            |
|                                                                  |
|                  Error Tolerance = .0001                         |
|                                                                  |
|   Estimate    Hit Probability    Aim Error                       |
|   ---------   ---------------    ---------                       |
|                                                                  |
|   Initial        ";OLDPROB;OLDSIGM;"                             |
|   User           ";USERPHIT;"  GUESS2;"                          |
|   User             -";SGUESS2;"                                  |
|   User           ";USERPHIT;"                                    |
|   Program          -";SGUESS;"                                   |
|   Final          ";NEWPROB;NEWSIGM;"                             |
|                                                                  |
```

Hit Any Key To Continue

```
9650     RETURN
9660     '
9670     ' DISPLAY ESTIMATION SUMMARY FOR AIM ERROR
9680     '
9690        GOSUB 11650                                     ' REFRESH SCREEN
9691        A$ =                      "\                                \###.##        #.##\          \"
9692        B$ =                      "\                                \###.##\                     \"
9693        C$ =                      "\                                      \       #.##\          \"
9700        PRINT                     "                  ________________________________________"
9710        PRINT                     "                 |                                        |"
9720        PRINT                     "                 |           ESTIMATION SUMMARY           |"
9730        PRINT                     "                 |           __________________           |"
9740        PRINT                     "                 |                                        |"
9750        PRINT                     "                 |   Estimate   Aim Error   Hit Probability |"
9760        PRINT                     "                 |   --------   ---------   --------------- |"
9765        PRINT                     "                 |                                        |"
9770        PRINT USING A$;           "                 |   Initial      ";OLDSIGM;OLDPROB;"     |"
9771        IF FLAG3 = 0 THEN GOTO 9790
9781        IF FLAG3 = 1 THEN PRINT USING B$;"       |   User         ";GUESS2;"      —      |"
9790        PRINT USING C$;           "                 |   Program        —";NEWPROB;"     |"
9800        PRINT USING A$;           "                 |   Final        ";NEWSIGM;NEWPROB:"     |"
9810        PRINT                     "                 |________________________________________|"
9820        PRINT " "
9830        PRINT                     "                       Hit Any Key To Continue"
9840        A$ = INKEY$ : IF A$ = "" THEN GOTO 9840
9850     RETURN
9991     '
10000    ' HIT PROBABILITY TOO LARGE
10010    '
10020       PRINT CHR$(7)
10040       PROB = OLDPROB
10050       SIGMA = OLDSIGM  : RS = RSTEMP
10060       GOSUB 11650                          ' REFRESH SCREEN
10061       PRINT "         ________________________________________________"
10062       PRINT "        |                                                |"
10070       PRINT "        |  Input Probability Too Large, Choose Smaller Value|"
10071       PRINT "        |________________________________________________|"
10072       PRINT " "
10080       INPUT "          Enter 'Y' To Choose Smaller Value Else Enter 'N' —) ",A$
10090       IF A$ = "Y" OR A$ = "y" THEN FLAG5 = 1 : GOTO 10280
10100       IF A$ = "N" OR A$ = "n" THEN FLAG5 = 2 : GOTO 10280 ELSE GOTO 10030
10120    '
10130    ' DERIVATIVE OF PROBABILITY IS ZERO
10140    '
10150       PRINT CHR$(7)
10170       SIGMA = OLDSIGM  : RS = RSTEMP
10180       PROB  = OLDPROB
10190       GOSUB 11650                          ' REFRESH SCREEN
10191       PRINT "        ______________________________________________"
10192       PRINT "       |                                              |"
10200       PRINT "       | Derivative Of Probability Function Went To Zero |"
10210       PRINT "       |                                              |"
10220       PRINT "       |        Aim Error Estimation Process 'DIED'   |"
10230       PRINT "       |______________________________________________|"
10231       PRINT " "
```

```
10240         INPUT "                  Enter 'Y' To Try Again Else Enter 'N' --> ";A$
10250         IF A$ = "Y" OR A$ = "y" THEN FLAG5 = 1 : GOTO 10290
10260         IF A$ = "N" OR A$ = "n" THEN FLAG5 = 2 ELSE GOTO 10190
10280       RETURN
10300     '
10310     ' DISPLAY HIT PROBABILITY BY RANGE TABLE FOR E & F SILOUETTE TARGETS
10320     '
10330         GOSUB 11650                        ' REFRESH SCREEN
10340         PRINT          "                    HIT PROBABILITY BY RANGE AND AIM ERROR"
10350         PRINT " "
10360         A$ =           "\                                  \"
10370         B$ =           "\                                                  \"
10380         C$ =           "\                              \##.##      ##.##      ##.##"
10390         D$ =           "\                              \##.##      ##.##      ##.##"
10400         PRINT USING B$;"          Theoretical Curves     1          2          3   "
10410         PRINT USING D$;"          Aim Error (mils)     ";SIGMA1(1);SIGMA1(2);SIGMA1(3)
10420         PRINT " "
10430         PRINT USING B$;"                                        Hit Probability"
10440         PRINT USING B$;"          Range (meters)          %          %          %   "
10450         PRINT USING C$;"               50             ";DAT(1,25);DAT(2,25);DAT(3,25)
10460         PRINT USING C$;"              100             ";DAT(1,50);DAT(2,50);DAT(3,50)
10470         PRINT USING C$;"              150             ";DAT(1,75);DAT(2,75);DAT(3,75)
10480         PRINT USING C$;"              200             ";DAT(1,100);DAT(2,100);DAT(3,100)
10490         PRINT USING C$;"              250             ";DAT(1,125);DAT(2,125);DAT(3,125)
10500         PRINT USING C$;"              300             ";DAT(1,150);DAT(2,150);DAT(3,150)
10510         PRINT USING C$;"              350             ";DAT(1,175);DAT(2,175);DAT(3,175)
10520         PRINT USING C$;"              400             ";DAT(1,200);DAT(2,200);DAT(3,200)
10530         PRINT " "
10540         PRINT          "          Select Theoretical Curve(s) To Display"
10550         PRINT " "
10560         PRINT          "          1 - Curve 1    4 - Curves 1 & 2    7 - Curves 1, 2, & 3"
10570         PRINT          "          2 - Curve 2    5 - Curves 1 & 3    8 - Quit"
10580         PRINT          "          3 - Curve 3    6 - Curves 2 & 3"
10590         PRINT " "
10595         INPUT          "                              Enter --> ";A$
10596         IF A$ = "" THEN GOTO 10330
10597         GM = VAL(A$)
10600         IF GM < 1 OR GM > 8 THEN GOTO 10330
10610     RETURN
10611     '
10612     ' DISPLAY Y AXIS LABELS FOR GRAPHIC ANALYSIS CARTESIAN GRAPH
10613     '
10620         LOCATE 6,3
10630         PRINT ".8"
10640         LOCATE 11,3
10650         PRINT ".6"
10655         LOCATE 13,3
10656         PRINT "PH"
10660         LOCATE 15,3
10670         PRINT ".4"
10680         LOCATE 20,3
10690         PRINT ".2"
10700     RETURN
10701     '
10702     ' DISPLAY X AXIS LABELS FOR GRAPHIC ANALYSIS CARTESIAN GRAPH
```

```
10703     '
10710           LOCATE 25,6
10711           PRINT "RGE"
10712           LOCATE 25,14
10720           PRINT "50"
10730           LOCATE 25,23
10740           PRINT "100"
10750           LOCATE 25,32
10760           PRINT "150"
10770           LOCATE 25,41
10780           PRINT "200"
10790           LOCATE 25,51
10800           PRINT "250"
10810           LOCATE 25,60
10820           PRINT "300"
10830           LOCATE 25,70
10840           PRINT "350"
10850       RETURN
10860     '
10870     ' DRAW CARTESIAN GRAPH FOR PARAMETER ANALYSIS MODULE
10880     '
10890           L = 0
10900           DRAW "BM 35,10"
10910           FOR M = 1 TO 179 STEP 6
10920               L = L + 1
10930               IF L = 5 THEN DRAW "D 6 NR 3" : L = 0 ELSE DRAW "D 6 NR 5"
10940           NEXT M
10950           FOR M = 1 TO 600 STEP 15
10960               L = L + 1
10970               IF L = 5 THEN DRAW "R 15 NU 6" : L = 0 ELSE DRAW "R 15 NU 3"
10980           NEXT M
10990           FOR M = 179 TO 1 STEP -6
11000               L = L + 1
11010               IF L = 5 THEN DRAW "U 6 NL 10" : L = 0 ELSE DRAW "U 6 NL 5"
11020           NEXT M
11030           FOR M = 600 TO 1 STEP -15
11040               L = L + 1
11050               IF L = 5 THEN DRAW "L 15 ND 6" : L = 0 ELSE DRAW "L 15 ND 3"
11060           NEXT M
11070       RETURN
11080     '
11090     ' DRAW CARTESIAN GRAPH FOR PARAMETER ANALYSIS MODULE
11100     '
11110          L = 0
11120          DRAW "BM 35,10"
11130          FOR M = 1 TO 179 STEP 6
11140              L = L + 1
11150              IF L = 6 THEN DRAW "D 6 NR 3" : L = 0 ELSE DRAW "D 6 NR 5"
11160          NEXT M
11170          FOR M = 1 TO 600 STEP 15
11180              L = L + 1
11190              IF  L = 5 THEN DRAW "R 15 NU 6" : L = 0 ELSE DRAW "R 15 NU 3"
11200          NEXT M
11210          FOR M = 179 TO 1 STEP -6
11220              L = L + 1
```

```
11230           IF L = 6 THEN DRAW "U 6 NL 9" : L = 0 ELSE DRAW "U 6 NL 5"
11240       NEXT M
11250       FOR M = 600 TO 1 STEP -15
11260           L = L + 1
11270           IF L = 5 THEN DRAW "L 15 ND 6" : L = 0 ELSE DRAW "L 15 ND 3"
11280       NEXT M
11290   RETURN
11300   '
11310   ' DRAW THEORETICAL CURVES FOR GRAPHIC ANALYSIS MODULE
11320   '
11330       IF ADDTC = 0 THEN GOTO 11450
11331       FOR I = PSTA TO PEND STEP SNO
11340           DRAW "BM="+VARPTR$(PLOTX(PSTA,1))+",="+VARPTR$(PLOTY(PSTA,1))
11350           FOR PK = 1 TO 200
11360               IF PK = 200 THEN GOTO 11380
11361               IF I = 1 THEN COLOR 2
11362               IF I = 2 THEN COLOR 4
11363               IF I = 3 THEN COLOR 14
11370               LINE -(PLOTX(I,PK+1),PLOTY(I,PK+1))
11380           NEXT PK
11390           IF I = 3 THEN PTR = 100
11400           IF I = 2 THEN PTR = 125
11410           IF I = 1 THEN PTR = 150
11420           GOSUB 13400     ' CONVERT SCREEN COORDINATE SYSTEM TO TEXT COORDINATE SYSTEM
11430           GOSUB 13490     ' OUTPUT SUPPORTING DOCUMENTATION FOR THEORETICAL CURVES
11440       NEXT I
11450   RETURN
11460   '
11470   ' DRAW EMPIRICAL CURVES FOR GRAPHIC ANALYSIS MODULE
11480   '
11490       IF ADDEC = 0 THEN GOTO 11550
11491       FOR I = 1 TO PLOTPT
11500           DRAW "BM="+VARPTR$(PLTXX(I))+",="+VARPTR$(PLTYX(I))  ' SET CURSOR TO START POINT
11510           DRAW "NU 3 ND 3 NL 5 NR 5"          ' DRAW CROSS HAIR TO INDICATE EMPIRICAL POINT
11520           IF I = PLOTPT THEN GOTO 11540
11530           LINE -(PLTXX(I+1),PLTYX(I+1))
11540       NEXT I
11550   RETURN
11641   '
11642   ' REFRESH SCREEN
11643   '
11650       CLS
11660       PRINT " "
11670       PRINT " "
11680       PRINT " "
11690       PRINT " "
11700       PRINT " "
11710       PRINT " "
11720       PRINT " "
11730       PRINT " "
11740       PRINT " "
11750       PRINT " "
11760   RETURN
11770   '
11780   ' DISPLAY EMPIRICAL DATA TABLE
```

```
11790        '
11800           PAGE = 1 : SLOOP = 1              ' FIRST TIME IN
11801           GOSUB 11820                       ' REFRESH SCREEN
11820           IF PAGE = 1 AND PLOTPT <= 10 THEN ENDL = PLOTPT
11803           IF PAGE = 1 AND PLOTPT > 10 THEN ENDL = 10
11804           IF PAGE = 2 AND PLOTPT <= 10 THEN ENDL = 10
11805           IF PAGE = 2 AND PLOTPT > 10 AND PLOTPT <= 20 THEN ENDL = PLOTPT
11806           IF PAGE = 2 AND PLOTPT > 20 THEN ENDL = 20
11807           IF PAGE = 3 AND PLOTPT <= 20 THEN ENDL = 20
11808           IF PAGE = 3 AND PLOTPT > 20 THEN ENDL = PLOTPT
11809           A$ =                                "                  ##            ####            #.##"
11810           B$ =                                "\      \#     \                                    \"
11820           PRINT USING B$:                     " PAGE #";PAGE;"          TABLE OF EMPIRICAL DATA POINTS"
11830           PRINT " "
11840           PRINT                               "                Point          Range       Hit Probability"
11850           PRINT                               "                  #          (1 - 400 m)       (0 - 1)"
11860           PRINT                               "              ------------------------------------------"
11870           FOR I = SLOOP TO ENDL
11900              PRINT USING A$;I;ADXPLT(I);ADYPLT(I)
11910           NEXT I
11920           PRINT                               "              ------------------------------------------"
11930           IF PAGE = 1 AND PLOTPT > 10 THEN PRINT          "                                  Continued Next Page"
11940           IF PAGE = 2 AND PLOTPT > 20 THEN PRINT          "                                  Continued Next Page"
11950        RETURN
11960        '
11970        ' IDENTIFY EDITING FUNCTIONS
11980        '
11990           PRINT " "
11991           PRINT                               "              1 - Page 1       4 - Add          7 - Retrieve"
12000           PRINT                               "              2 - Page 2       5 - Delete       8 - Store"
12010           PRINT                               "              3 - Page 3       6 - Modify       9 - Quit"
12020           PRINT " "
12030           INPUT                               "                                  Enter --) ";EDT
12040           IF EDT < 1 OR EDT > 9 THEN GOTO 11800
12041           IF EDT = 1 THEN PAGE = 1 : SLOOP = 1 : GOTO 12056
12042           IF EDT = 2 THEN PAGE = 2 : SLOOP = 11 : GOTO 12056
12043           IF EDT = 3 THEN PAGE = 3 : SLOOP = 21 : GOTO 12056
12050           IF EDT = 4 THEN GOSUB 12100
12051           IF EDT = 5 THEN GOSUB 12270
12052           IF EDT = 6 THEN GOSUB 12420
12053           IF EDT = 7 THEN GOSUB 12690
12054           IF EDT = 8 THEN GOSUB 12800
12055           IF EDT = 9 THEN GOTO 12060
12056           GOSUB 11801
12057           GOSUB 11990
12060        RETURN
12070        '
12080        ' ADD A RECORD OF EMPIRICAL DATA
12090        '
12100           PLOTPT = PLOTPT + 1                 ' INCREMENT TOTAL EMPIRICAL POINTS
12101           IF PLOTPT > 30 THEN PLOTPT = 30 : GOTO 12230
12110           I = PLOTPT                          ' SET POINTER TO NEXT AVAILABLE STORAGE LOCATION
12120           SCFUNC = 0                          ' CLEAR LOOP AROUND FLAG
12130           GOSUB 13600                         ' DEFINE TARGET RANGE & HIT PROBABILITY COORDINATES
12230        RETURN
```

```
12240       '
12250       ' DELETE A RECORD OF EMPIRICAL DATA
12260       '
12270           GOSUB 11801
12271           PRINT " "
12280           PRINT "                    Enter Point Number To Be Deleted"
12281           PRINT " "
12282           INPUT "                    Or Enter (cr) To Quit --) ";A$
12283           IF A$ = "" THEN GOTO 12380
12284           DELNO = VAL(A$)
12290           IF DELNO < 1 OR DELNO > PLOTPT THEN GOTO 12270
12300           K = 0
12310           FOR I = 1 TO PLOTPT
12320               IF I = DELNO THEN GOTO 12360
12330               K = K + 1
12340               ADXPLT(K) = ADXPLT(I)
12350               ADYPLT(K) = ADYPLT(I)
12360           NEXT I
12370           PLOTPT = PLOTPT - 1
12371           GOSUB 12520                         ' SORT RANGE AND HIT PROBABILITY IN ASCENDING ORDER
12372           GOSUB 12600                         ' CONVERT RANGE AND HIT PROBABILITY TO SCREEN COORDINATE
12380       RETURN
12390       '
12400       ' MODIFY A RECORD OF EMPIRICAL DATA
12410       '
12420           GOSUB 11801
12421           PRINT " "
12430           INPUT                   "                    Enter Point Number To Modify --) ";I
12431           IF I < 1 OR I > PLOTPT THEN GOTO 12420
12432           GOSUB 11650                         ' REFRESH SCREEN
12441           A$ =                    "                ##            ####            #.##"
12442           B$ =                    "\      \#     \                                    \"
12443           PRINT USING B$:         " PAGE #":PAGE:"        TABLE OF EMPIRICAL DATA POINTS"
12444           PRINT " "
12445           PRINT                   "                  Point          Range       Hit Probability"
12446           PRINT                   "                    #          (1 - 400 m)       (0 - 1)"
12447           PRINT                   "                 ------------------------------------------"
12448           PRINT USING A$:I:ADXPLT(I):ADYPLT(I)*.01
12449           PRINT                   "                 ------------------------------------------"
12450           PRINT " "
12451           PRINT                   "                  ------------------------------------------
12452           PRINT                   "                 |                                          |"
12453           PRINT                   "                 |       Enter Modification Option          |"
12454           PRINT                   "                 |                                          |"
12455           PRINT                   "                 |       Range ..................... 1       |"
12456           PRINT                   "                 |       Hit Probability ............ 2       |"
12457           PRINT                   "                 |       Range & Hit Probability ..... 3       |"
12458           PRINT                   "                 |       Quit ...................... 4       |"
12459           PRINT                   "                 |__________________________________________|"
12460           PRINT " "
12461           INPUT                   "                                    Enter --) ";SCID
12462           IF SCID = 1 THEN SCFUNC = 1 : GOSUB 13600 : GOTO 12466
12463           IF SCID = 2 THEN SCFUNC = 0 : GOSUB 13750 : GOTO 12466
12464           IF SCID = 3 THEN SCFUNC = 0 : GOSUB 13600 : GOTO 12466
12465           IF SCID = 4 THEN GOTO 12467
```

```
12466          GOTO 12432
12467       RETURN
12511       '
12512       ' SORT EMPIRICAL DATA IN ASCENDING ORDER FOR TARGET RANGE
12513       '
12520          K = 1
12530          FOR IP = 1 TO PLOTPT-1
12540             K = K + 1
12550             FOR J = K TO PLOTPT
12560                IF ADXPLT(IP) ( ADXPLT(J) THEN GOTO 12570
12561                DUMMY = ADXPLT(J)
12562                DUMMY1 = ADYPLT(J)
12563                ADXPLT(J) = ADXPLT(IP)
12564                ADYPLT(J) = ADYPLT(IP)
12565                ADXPLT(IP) = DUMMY
12566                ADYPLT(IP) = DUMMY1
12570             NEXT J
12580          NEXT IP
12590       RETURN
12591       '
12592       ' CONVERT EMPIRICAL DATA TO CARTESIAN POINT SYSTEM
12593       '
12600          FOR IP = 1 TO PLOTPT
12610             IF TGTNO (= 2 THEN PLTXX(IP) = 35 + INT((ADXPLT(IP)/2) * 3)
12620             IF TGTNO ) 2 THEN PLTXX(IP) = 35 + INT((ADXPLT(IP)/20) * 3)
12630             PLTYX(IP) = INT((10 - 179 * (ADYPLT(IP)/100))) + 179
12640          NEXT IP
12650       RETURN
12660       '
12670       ' EXTRACTS EMPIRICAL DATA FROM FILE
12680       '
12690          IF TGTNO (= 2 THEN OPEN "I",#1,"POINTS.SIL"   ' OPENS FILE FOR E & F SILOUETTE TARGETS
12700          IF TGTNO ) 2 THEN OPEN "I",#1,"POINTS.TNK"    ' OPENS FILE FOR TANK FRONT & SIDE TARGETS
12710          INPUT #1,PLOTPT                  ' NUMBER OF POINTS TO EXTRACT
12720          FOR I = 1 TO PLOTPT
12730             INPUT #1,ADXPLT(I),ADYPLT(I)  ' EXTRACT POINTS FROM FILE
12740          NEXT I
12750          CLOSE 1
12751          GOSUB 12520                      ' SORT POINTS IN ASCENDING ORDER
12752          GOSUB 12600                      ' CONVERT POINTS TO CARTESIAN POINT SYSTEM
12760       RETURN
12770       '
12780       ' STORES EMPIRICAL DATA INTO FILE
12790       '
12800          IF TGTNO (= 2 THEN OPEN "O",#1,"POINTS.SIL"
12810          IF TGTNO ) 2 THEN OPEN "O",#1,"POINTS.TNK"
12820          WRITE #1,PLOTPT                  ' NUMBER OF POINTS TO SAVED
12830          FOR I = 1 TO PLOTPT
12840             WRITE #1,ADXPLT(I),ADYPLT(I)  ' POINTS SAVED
12850          NEXT I
12860          CLOSE 1
12870       RETURN
12880       '
12890       ' DISPLAY HIT PROBABILITY BY RANGE TABLE FOR TANK TARGETS
12900       '
```

```
12910         GOSUB 11650                        ' REFRESH SCREEN
12920         PRINT          "                    HIT PROBABILITY BY RANGE AND AIM ERROR"
12930         PRINT " "
12940         A$ =           "\                                  \"
12950         B$ =           "\                                                      \"
12960         C$ =           "\                              \##.##       ##.##       ##.##"
12970         D$ =           "\                              \##.##       ##.##       ##.##"
12980         PRINT USING B$;"          Theoretical Curves     1            2           3   "
12990         PRINT USING D$;"          Aim Error (mils)      ";SIGMA1(1):SIGMA1(2):SIGMA1(3)
13000         PRINT " "
13010         PRINT USING B$;"                                        Hit Probability"
13020         PRINT USING B$;"          Range (meters)          %           %           %   "
13030         PRINT USING C$;"               500              ";DAT(1,25):DAT(2,25):DAT(3,25)
13040         PRINT USING C$,"              1000              ";DAT(1,50):DAT(2,50):DAT(3,50)
13050         PRINT USING C$;"              1500              ";DAT(1,75);DAT(2,75):DAT(3,75)
13060         PRINT USING C$:"              2000              ";DAT(1,100):DAT(2,100):DAT(3,100)
13070         PRINT USING C$;"              2500              ";DAT(1,125):DAT(2,125):DAT(3,125)
13080         PRINT USING C$:"              3000              ";DAT(1,150):DAT(2,150):DAT(3,150)
13090         PRINT USING C$;"              3500              ";DAT(1,175):DAT(2,175):DAT(3,175)
13100         PRINT USING C$;"              4000              ";DAT(1,200):DAT(2,200):DAT(3,200)
13112         PRINT " "
13113         PRINT          "          Select Theoretical Curve(s) To Display"
13114         PRINT " "
13120         PRINT          "          1 - Curve 1    4 - Curves 1 & 2    7 - Curves 1, 2, & 3"
13130         PRINT          "          2 - Curve 2    5 - Curves 1 & 3    8 - Quit"
13140         PRINT          "          3 - Curve 3    6 - Curves 2 & 3"
13150         PRINT " "
13161         INPUT          "                                  Enter --> ";A$
13162         IF A$ = "" THEN GOTO 12910
13163         GM = VAL(A$)
13170         IF GM < 1 OR GM > 8 THEN GOTO 12910
13180      RETURN
13190      '
13200      ' DISPLAY X AXIS LABELS FOR TANK TARGET MAXIMUM RANGES
13210      '
13220         LOCATE 25,6
13221         PRINT "RGE"
13222         LOCATE 25,13
13230         PRINT "500"
13240         LOCATE 25,22
13250         PRINT "1000"
13260         LOCATE 25,31
13270         PRINT "1500"
13280         LOCATE 25,40
13290         PRINT "2000"
13300         LOCATE 25,50
13310         PRINT "2500"
13320         LOCATE 25,59
13330         PRINT "3000"
13340         LOCATE 25,69
13350         PRINT "3500"
13360      RETURN
13370      '
13380      ' CONVERT GRAPHICS SCREEN COORDINATE SYSTEM INTO TEXT COORDINATE SYSTEM
13390      '
```

```
13400        COL = INT(.1244 * PLOTX(I,PTR) + 3.336)
13410        ROW = INT(.1166 * PLOTY(I,PTR) + 2.1)
13420        IF ROW >= 3 AND ROW <= 6 THEN ROW = ROW + 1
13430        IF ROW >= 7 AND ROW <= 9 THEN ROW = ROW - 2
13440        IF ROW >= 10 AND ROW <= 24 THEN ROW = ROW - 1
13450     RETURN
13460     '
13470     ' DISPLAY SUPPORTING DOCUMENTATION FOR GRAPHIC ANALYSIS MODULE
13480     '
13490        DRAW "BM="+VARPTR$(PLOTX(I,PTR))+",="+VARPTR$(PLOTY(I,PTR))
13500        IF PLOTY(I,PTR) < 26 THEN DRAW "D 8 R 8 BR 3" ELSE DRAW "U 8 R 8 BR3"
13510        LOCATE ROW,COL
13511        IF I = 1 AND GM = 1 THEN PRINT "CURVE 1" : LOCATE 1,33 : PRINT USING "CURVE 1 = ##.## mils";SIGMA1(1)
13512        IF I = 2 AND GM = 2 THEN PRINT "CURVE 2" : LOCATE 1,33 : PRINT USING "CURVE 2 = ##.## mils";SIGMA1(2)
13513        IF I = 3 AND GM = 3 THEN PRINT "CURVE 3" : LOCATE 1,33 : PRINT USING "CURVE 3 = ##.## mils";SIGMA1(3)
13514        IF I = 1 AND GM = 4 THEN PRINT "CURVE 1" : LOCATE 1,20 : PRINT USING "CURVE 1 = ##.## mils";SIGMA1(1)
13515        IF I = 2 AND GM = 4 THEN PRINT "CURVE 2" : LOCATE 1,45 : PRINT USING "CURVE 2 = ##.## mils";SIGMA1(2)
13516        IF I = 1 AND GM = 5 THEN PRINT "CURVE 1" : LOCATE 1,20 : PRINT USING "CURVE 1 = ##.## mils";SIGMA1(1)
13517        IF I = 3 AND GM = 5 THEN PRINT "CURVE 3" : LOCATE 1,45 : PRINT USING "CURVE 3 = ##.## mils";SIGMA1(3)
13518        IF I = 2 AND GM = 6 THEN PRINT "CURVE 2" : LOCATE 1,20 : PRINT USING "CURVE 2 = ##.## mils";SIGMA1(2)
13519        IF I = 3 AND GM = 6 THEN PRINT "CURVE 3" : LOCATE 1,45 : PRINT USING "CURVE 3 = ##.## mils";SIGMA1(3)
13520        IF I = 1 AND GM = 7 THEN PRINT "CURVE 1" : LOCATE 1,8 : PRINT USING "CURVE 1 = ##.## mils";SIGMA1(1)
13530        IF I = 2 AND GM = 7 THEN PRINT "CURVE 2" : LOCATE 1,33 : PRINT USING "CURVE 2 = ##.## mils";SIGMA1(2)
13540        IF I = 3 AND GM = 7 THEN PRINT "CURVE 3" : LOCATE 1,58 : PRINT USING "CURVE 3 = ##.## mils";SIGMA1(3)
13550     RETURN
13560     '
13570     ' DEFINE EMPIRICAL DATA USING THE ENTER FUNCTION
13580     '
13590        I = 0
13591        SCFUNC = 2
13600        GOSUB 11650                                  ' REFRESH SCREEN
13602        PRINT " "
13610        PRINT                   "                  ______________________________"
13620        PRINT                   "                 |                              |"
13630        IF TGTNO <= 2 THEN PRINT "                 |   Enter Target Range (1 - 400 m)    |"
13640        IF TGTNO > 2 THEN PRINT  "                 |   Enter Target Range (1 - 4000 m)   |"
13650        PRINT                   "                 |                              |"
13660        PRINT                   "                 |   Or Enter (cr) To Quit      |"
13670        PRINT                   "                 |______________________________|"
13680        PRINT " "
13690        INPUT                   "                           Enter --> ";A$
13700        IF A$ = "" AND I = 0 THEN PLOTPT = 0 : GOTO 13870
13701        IF A$ = "" AND I > 0 THEN PLOTPT = I : GOTO 13850
13702        IF SCFUNC = 2 THEN I = I + 1
13703        IF I > 30 THEN PLOTPT = 30 : GOTO 13850
13710        ADXPLT(I) = VAL(A$)
13720        IF TGTNO <= 2 THEN IF ADXPLT(I) < 1 OR ADXPLT(I) > 400 THEN GOTO 13600
13730        IF TGTNO > 2 THEN IF ADXPLT(I) < 1 OR ADXPLT(I) > 4000 THEN GOTO 13600
13740        IF SCFUNC = 1 THEN GOTO 13850
13750        GOSUB 11650                                  ' REFRESH SCREEN
13760        PRINT "          _____________________________"
13770        PRINT "         |                             |"
13780        PRINT "         |   Enter Hit Probability (0 - 1)   |"
13790        PRINT "         |_____________________________|"
13800        PRINT " "
```

```
13810         INPUT "                                Enter --) ";ADYPLT(I)
13820         ADYPLT(I) = ADYPLT(I)*100
13830         IF ADYPLT(I) < 1 OR ADYPLT(I) > 100 THEN GOTO 13750
13835         IF SCFUNC < 2 THEN GOTO 13850
13840         GOTO 13600
13850         GOSUB 12520                              'SORT POINTS BY X COORDINATE IN ASCENDING ORDER
13860         GOSUB 12600                              'CONVERT POINTS TO CARTESIAN POINT SYSTEM
13870       RETURN
15130       '
15140       ' IDENTIFY WHETHER TO INCLUDE OR EXCLUDE EMPIRICAL DATA FROM PLOT
15150       '
15160         IF ADDEC = 1 THEN ADDEC = 0 : STSEC$ = "EXCLUDED" : GOTO 15171    ' EXCLUDE EMPIRICAL DATA FROM PLOT
15170         IF ADDEC = 0 THEN ADDEC = 1 : STSEC$ = "INCLUDED"                 ' INCLUDE EMPIRICAL DATA FROM PLOT
15171       RETURN
15172       '
15173       ' IDENTIFY WHETHER TO INCLUDE OR EXCLUDE THEORETICAL DATA FROM PLOT
15174       '
15175         IF ADDTC = 1 THEN ADDTC = 0 : STSTC$ = "EXCLUDED" : GOTO 15177    ' EXCLUDE THEORETICAL DATA FROM PLOT
15176         IF ADDTC = 0 THEN ADDTC = 1 : STSTC$ = "INCLUDED"                 ' INCLUDE THEORETICAL DATA FROM PLOT
15177       RETURN
15181       '
15182       ' DISPLAY GRAPHIC ANALYSIS MODULE THEORETICAL/EMPIRICAL GRAPHS
15183       '
15190         CLS
15200         COLOR 15
15230         IF TGTNO <= 2 THEN GOSUB 10710             ' OUTPUT X LABELS (RANGE OF E OR F SILOUETTE TARGETS) FOR GRAPH
15240         IF TGTNO > 2 THEN GOSUB 13220              ' OUTPUT X LABELS (RANG OF TANK TGTS) FOR GRAPH
15250         GOSUB 10620                                ' OUTPUT Y LABELS (HIT PROBABILITY VALUES) FOR GRAPH
15260         GOSUB 11110                                ' OUTPUT GRAPH
15261         GOSUB 11490                                ' DRAW EMPIRICAL POINTS AND LINES
15270         GOSUB 11330                                ' DRAW THEORETICAL LINES TO GRAPH
15271         COLOR 15
15280         A$ = INKEY$ : IF A$ = "" GOTO 15280
15290       RETURN
15550       '
15560       ' DEFINE AIM ERROR FOR EACH THEORETICAL CURVE FOR GRAPHIC ANALYSIS MODULE
15570       '
15580         IF TGTNO > 2 THEN ISTA = 20 : IEND = 4000 : ISTEP = 20
15581         IF TGTNO <= 2 THEN ISTA = 2 : IEND = 400 : ISTEP = 2
15601         NUM = 0
15602         IF GORND = 1 THEN GOTO 15640
15603         GOSUB 15770
15604         IF TAEID >= 2 THEN GOTO 15730
15605         GOSUB 11650                              ' REFRESH SCREEN
15606         B$ =                          "\                                        \###.##\        \"
15607         PRINT                         "                                                          "
15608         PRINT                         "  ------------------------------------------------------  !"
15609         IF PM = 1 THEN PRINT USING B$;"  !  Current Aim Error For 1st Curve ";SIGMA1(PM);" mils  !"
15610         IF PM = 2 THEN PRINT USING B$;"  !  Current Aim Error For 2nd Curve ";SIGMA1(PM);" mils  !"
15611         IF PM = 3 THEN PRINT USING B$;"  !  Current Aim Error For 3rd Curve ";SIGMA1(PM);" mils  !"
15612         PRINT                         "  !                                                      !"
15613         PRINT                         "  !  Enter (cr) To Keep Current Value                    !"
15614         PRINT                         "  !                                                      !"
15615         PRINT                         "  !  Or Enter New Aim Error (in mils)                    !"
15616         PRINT                         "  ------------------------------------------------------  !"
```

```
15517         PRINT
15518         INPUT                                                    Enter --) ";A$
15526         IF A$ = "" THEN GOTO 15730
15527         SIGMA1(PM) = VAL(A$)
15529         GOTO 15710
15530     '
15535     ' DEFINE THEORETICAL HIT PROBABILITY FOR EACH AIM ERROR AND RANGE
15537     '
15540         IF SIGMA1(PM) = 0 THEN SIGMA1(PM) = .0000:
15541         FOR RG = 1000 TO 15000 STEP 1000
15550             NUM = NUM + 1
15560             RG = RG + SIGMA1(PM) / 1200
15570             GOSUB 870                          ' ESTABLISH HIT PROBABILITY
15580             DAT(PM,NUM) = PROB
15590             PLOTX(PM,NUM) = 35 + NUM * 3
15700             PLOTY(PM,NUM) = (+10 - 175 * DAT(PM,NUM)) + 179
15710         NEXT RG
15730     RETURN
15740     '
15750     ' DETERMINE MANNER IN WHICH AIM ERROR IS TO BE COMPUTED
15760     '
15770         GOSUB 11650                            ' REFRESH SCREEN
15772         PRINT "                 ------------------------------------------------"
15773         PRINT "                |                                                |"
15781         PRINT "                |   Select Error Estimation Option               |"
15782         PRINT "                |                                                |"
15790         PRINT "                |        Enter Total Aim Error ..............  1  |"
15800         PRINT "                |        Estimate Error From Component(s) ....  2  |"
15801         PRINT "                |        Retrieve Prior Estimates ...........  3  |"
15802         PRINT "                |        Quit ...............................  4  |"
15806         PRINT "                |________________________________________________|"
15807         PRINT " "
15810         INPUT "                                  Enter --) ";TAEID
15820         IF TAEID < 1 OR TAEID > 4 THEN GOTO 15770
15830         IF TAEID = 1 OR TAEID = 4 THEN GOTO 15950
15831         IF TAEID = 2 THEN GOTO 15840
15832         GOSUB 17420                            ' RETRIEVE AIMING COMPONENT ESTIMATE DATA
15835         GOTO 15930                             ' DEVELOP TOTAL AIM ERROR
15840         IK = 0                                 ' INITIALIZE COUNTER
15860         GOSUB 16030                            ' DISPLAY AIMING COMPONENT NAME MENU AND NAME COMPONENT
15870         IF CMPID = 13 THEN FACTOR(PM) = IK : GOTO 15930
15880         GOSUB 11650                            ' REFRESH SCREEN
15881         A$ =          "\                                \&\   \"
15882         PRINT         "                  ------------------------------------------"
15883         PRINT         "                 |                                          |"
15886         PRINT USING A$;"                 |  Component Name ";LNAME$(PM,IK);"        |"
15905         PRINT         "                 |                                          |"
15906         PRINT         "                 |  Enter Value (in mils)                   |"
15907         PRINT         "                 |__________________________________________|"
15908         PRINT " "
15910         INPUT         "                                  Enter --) ";CVALUE(PM,IK)
15920         GOTO 15860
15930         IF FACTOR(PM) = 0 THEN GOTO 15770      ' ESTIMATE DATA WASN'T CREATED
15931         GOSUB 17320                            ' COMPUTE TOTAL ESTIMATED AIM ERROR
15940         GOSUB 16550                            ' DISPLAY AIMING ERROR COMPONENT STATUS MENU
```

```
15941         GOSUB 16653                          ' DISPLAY MENU FUNCTIONS
15950       RETURN
16000       '
16010       ' DISPLAY AIMING COMPONENT NAME MENU
16020       '
16030         GOSUB 11650                          ' REFRESH SCREEN
16031         A$ =          "\                                    \##\          \"
16032         PRINT         "                    _____________________________________"
16033         PRINT         "                   |                                     |"
16040         PRINT         "                   |        Enter Up To 30 Components    |"
16041         PRINT         "                   |                                     |"
16042         PRINT USING A$;"                  |        Entering Component ";IK+1;"          |"
16050         PRINT         "                   |                                     |"
16060         PRINT         "                   |     Weapon/Round Dispersion ..... 1 |"
16070         PRINT         "                   |     Firing Position ............. 2 |"
16080         PRINT         "                   |     Trigger Control ............. 3 |"
16090         PRINT         "                   |     Breath Control .............. 4 |"
16100         PRINT         "                   |     Physical Condition .......... 5 |"
16110         PRINT         "                   |     Stress ...................... 6 |"
16120         PRINT         "                   |     Suppressive Fire ............ 7 |"
16130         PRINT         "                   |     Target Range ................ 8 |"
16140         PRINT         "                   |     Target Speed ................ 9 |"
16150         PRINT         "                   |     Target Size ................. 10 |"
16160         PRINT         "                   |     Target Exposure Time ........ 11 |"
16170         PRINT         "                   |     User Defined Component(s) .... 12 |"
16171         PRINT         "                   |     Quit ........................ 13 |"
16180         PRINT         "                   |_____________________________________|"
16181         PRINT " "
16190         INPUT         "                                        Enter --) ";CMPID
16200         IF CMPID < 1 OR CMPID > 13 THEN GOTO 16030
16210       '
16220       ' SET COMPONENT NAME
16230       '
16231         IF CMPID = 13 THEN GOTO 16510
16232         IK = IK + 1
16233         IF IK > 30 THEN GOTO 16030
16240         IF CMPID = 1 THEN CNAME$(PM,IK) = "Weapon/Round Dispersion"
16250         IF CMPID = 2 THEN CNAME$(PM,IK) = "Firing Position        "
16260         IF CMPID = 3 THEN CNAME$(PM,IK) = "Trigger Control        "
16270         IF CMPID = 4 THEN CNAME$(PM,IK) = "Breath Control         "
16280         IF CMPID = 5 THEN CNAME$(PM,IK) = "Physical Condition     "
16290         IF CMPID = 6 THEN CNAME$(PM,IK) = "Stress                 "
16300         IF CMPID = 7 THEN CNAME$(PM,IK) = "Suppressive Fire       "
16310         IF CMPID = 8 THEN CNAME$(PM,IK) = "Target Range           "
16320         IF CMPID = 9 THEN CNAME$(PM,IK) = "Target Speed           "
16330         IF CMPID = 10 THEN CNAME$(PM,IK) = "Target Size            "
16340         IF CMPID = 11 THEN CNAME$(PM,IK) = "Target Exposure Time   "
16345         IF CMPID <= 11 THEN GOTO 16510
16346       '
16347       ' SET COMPONENT NAMES ASSOCIATED VALUE
16348       '
16350         GOSUB 11650                          ' REFRESH SCREEN
16351         PRINT "                   _____________________________________________"
16352         PRINT "                  |                                             |"
16360         PRINT "                  |      User Defined Component                 |"
```

```
16361       PRINT "          |                                                    "
16362       PRINT "          |     Enter Component Name (Up To 23 Characters)     "
16370       PRINT "          |____________________________________________________"
16371       PRINT " "
16380       INPUT "                                Enter --) ";CNAME$(PM,IK)
16390       V = LEN(CNAME$(PM,IK))
16400       IF V ) 23 OR V = 0 THEN GOTO 16350                  ' ERROR HANDLING
16410       IF V ( 23 THEN GOTO 16430
16420       GOTO 16510
16430       V1 = 23 - V
16450       CNAME$(PM,IK) = CNAME$(PM,IK)+BLANK$(V1)
16510   RETURN
16520   '
16530   ' DISPLAY COMPONENT AIMING ERROR STATUS MENU
16540   '
16550       PAGE = 1 : SLOOP = 1            ' FIRST TIME IN
16551       GOSUB 11650                     ' REFRESH SCREEN
16552       IF PAGE = 1 AND TFACTOR(PM) (= 10 THEN ENDL = TFACTOR(PM)
16553       IF PAGE = 1 AND TFACTOR(PM) ) 10 THEN ENDL = 10
16554       IF PAGE = 2 AND TFACTOR(PM) (= 10 THEN ENDL = 10
16555       IF PAGE = 2 AND TFACTOR(PM) ) 10 AND TFACTOR(PM) (= 20 THEN ENDL = TFACTOR(PM)
16556       IF PAGE = 2 AND TFACTOR(PM) ) 20 THEN ENDL = 20
16557       IF PAGE = 3 AND TFACTOR(PM) (= 20 THEN ENDL = 20
16558       IF PAGE = 3 AND TFACTOR(PM) ) 20 THEN ENDL = TFACTOR(PM)
16559       C$ =                            "\      \#\                                        \"
16560       PRINT USING C$;                 " PAGE # ";PAGE;"              TOTAL ESTIMATED AIM ERROR"
16570       PRINT " "
16571       A$ =                            "\                                                \     ##.##"
16580       B$ =                            "              ##          :                      \     ##.##"
16590       PRINT                           "            COMPONENT    COMPONENT                    COMPONENT"
16600       PRINT                           "              NO.          NAME                       VALUE"
16610       PRINT                           "            ------------------------------------------------"
16620       FOR J = SLOOP TO ENDL
16630           PRINT USING B$;J;CNAME$(PM,J);CVALUE(PM,J)
16640       NEXT J
16641       PRINT                           "            ------------------------------------------------"
16642       IF PAGE = 1 AND TFACTOR(PM) ) 10 THEN PRINT "                                  Continued Next Page" : GOTO 16648
16643       IF PAGE = 2 AND TFACTOR(PM) ) 20 THEN PRINT "                                  Continued Next Page" : GOTO 16648
16646       IF GTYPE = 2 THEN PRINT USING A$:"                        Total Error              ";SIGMA1(PM)
16647       IF GTYPE = 1 THEN PRINT USING A$:"                        Total Error              ";SIGMA
16648       PRINT " "
16649   RETURN
16650   '
16651   ' DISPLAY MENU FUNCTION ID INFORMATION
16652   '
16653       PRINT "              1 - Page 1        4 - Add          7 - Retrieve"
16654       PRINT "              2 - Page 2        5 - Delete       8 - Store"
16657       PRINT "              3 - Page 3        6 - Modify       9 - Quit"
16660       PRINT " "
16661       INPUT "                                Enter --) ";MENUID
16662       IF MENUID = 1 THEN PAGE = 1 : SLOOP = 1 : GOTO 16730
16663       IF MENUID = 2 THEN PAGE = 2 : SLOOP = 11 : GOTO 16730
16664       IF MENUID = 3 THEN PAGE = 3 : SLOOP = 21 : GOTO 16730
16670       IF MENUID = 4 THEN GOSUB 16860 : GOSUB 17320
16680       IF MENUID = 5 THEN GOSUB 17030 : GOSUB 17320
```

```
16690       IF MENUID = 6 THEN GOSUB 17180 : GOSUB 17320
16700       IF MENUID = 7 THEN GOSUB 17423 : GOSUB 17320
16710       IF MENUID = 8 THEN GOSUB 17800
16726       IF MENUID = 9 THEN GOTO 16740
16730       GOSUB 16551
16731       GOSUB 16653
16740   RETURN
16830   '
16840   ' ADD A COMPONENT RECORD

16850   '
16860       TCFUNC = 0
16870       IK = TFACTOR(PM)
16880       GOSUB 16030                          ' DISPLAY AIMING COMPONENT NAME MENU
16890       IF CMPID = 13 THEN GOTO 16990
16900       IF TCFUNC = 1 THEN GOTO 16990
16910       IF TCFUNC = 2 THEN GOTO 16935
16920       TFACTOR(PM) = TFACTOR(PM) + 1
16935       GOSUB 11650                          ' REFRESH SCREEN
16936       A$ =          "\                          \#\       \"
16937       PRINT         "                 ------------------------------------------------"
16938       PRINT         "                 |                                              |"
16941       PRINT USING A$;"                 |     Component Name ";CNAME$(PM,IK);"       |"
16942       PRINT         "                 |                                              |"
16943       PRINT         "                 |     Enter Value (in mils)                    |"
16945       PRINT         "                 |______________________________________________|"
16946       PRINT " "
16950       INPUT         "                                  Enter --) ";CVALUE(PM,IK)
16990   RETURN
17000   '
17010   ' DELETE A COMPONENT RECORD
17020   '
17030       GOSUB 16551
17040       PRINT "                     Enter Component Number To Be Deleted"
17041       PRINT " "
17042       INPUT "                     Or Enter (cr) To Quit --) ";A$
17043       IF A$ = "" THEN GOTO 17140
17044       DELNO = VAL(A$)
17045       IF DELNO < 1 OR DELNO > TFACTOR(PM) THEN GOTO 17030
17060       K = 0
17070       FOR I = 1 TO TFACTOR(PM)
17080           IF I = DELNO THEN GOTO 17120
17090           K = K + 1
17100           CNAME$(PM,K) = CNAME$(PM,I)
17110           CVALUE(PM,K) = CVALUE(PM,I)
17120       NEXT I
17121       CNAME$(PM,TFACTOR(PM)) = " "
17122       CVALUE(PM,TFACTOR(PM)) = 0
17130       TFACTOR(PM) = TFACTOR(PM) - 1
17140   RETURN
17150   '
17160   ' MODIFY A COMPONENT RECORD (NAME OR VALUE OR BOTH)
17170   '
17180       GOSUB 16551
17190       INPUT "                 Enter Component Number To Be Modified --) ";IK
```

```
17191       IF IK ( 1 OR IK ) TFACTOR(PM) THEN GOTO 17180
17192       GOSUB 11650
17195       B$ =                          "          ##      \                    \    ###.##"
17197       PRINT                         "        COMPONENT  COMPONENT                 COMPONENT"
17198       PRINT                         "          NO.      NAME                      VALUE"
17199       PRINT                         "  ------------------------------------------------------"
17200       PRINT USING B$;IK;CNAME$(PM, IK);CVALUE(PM, IK)
17201       PRINT                         "  ------------------------------------------------------"
17210       PRINT " "
17211       PRINT                         "                                                        "
17212       PRINT                         "                  |------------------------------------|"
17220       PRINT                         "                  |      Enter Modification Option     |"
17221       PRINT                         "                  |                                    |"
17225       PRINT                         "                  |      Name ..................  1   |"
17226       PRINT                         "                  |      Value .................  2   |"
17227       PRINT                         "                  |      Name & Value ..........  3   |"
17228       PRINT                         "                  |      Quit ..................  4   |"
17229       PRINT                         "                  |------------------------------------|"
17230       PRINT " "
17231       INPUT                         "                                  Enter --) ";SCID
17240       IF SCID = 1 THEN TCFUNC = 1 : IK = IK - 1 : GOSUB 16880 : TCFUNC = 0 : GOTO 17200
17250       IF SCID = 2 THEN TCFUNC = 0 : GOSUB 16935 : GOTO 17230
17260       IF SCID = 3 THEN TCFUNC = 2 : IK = IK - 1 : GOSUB 16880 : TCFUNC = 0 : GOTO 17200
17270       IF SCID = 4 THEN GOTO 17280
17271       GOTO .7192
17280   RETURN
17290   '
17300   ' COMPUTE TOTAL ESTIMATED AIM ERROR FOR PARAMETER AND GRAPHIC ANALYSIS MODULES
17310   '
17320       FOR I = 1 TO TFACTOR(PM)
17330           AET = AET + CVALUE(PM,I)^2
17340       NEXT I
17350       AET = SQR(AET)
17360       IF GTYPE = 1 THEN SIGMA = AET
17370       IF GTYPE = 2 THEN SIGMA1(PM) = AET
17380       AET = 0
17390   RETURN
17400   '
17410   ' RETRIEVE COMPONENT ESTIMATES FROM FILE
17420   '
17422   '
17423       IF GTYPE = 1 THEN OPEN "I",#1,"AEMDL.EST" : PK = 1 ELSE OPEN "I",#1,"AEDAM.EST" : PK = 3
17424       FOR J = 1 TO PK
17425           IF J <> PM THEN GOTO 17434
17426           INPUT #1, TFACTOR(J)                    ' NUMBER OF COMPONENTS TO EXTRACT
17427           TDUMMY(J) = TFACTOR(J)                  ' SAVE NUMBER OF COMPONENTS IN DUMMY FIELD
17428           FOR I = 1 TO 30                         ' EXTRACT ALL AIM ERROR COMPONENT NAMES AND VALUES PREVIOUSLY DEFINED
17429               INPUT #1, CNAME$(J,I), CVALUE(J,I)  ' EXTRACT COMPONET NAME AND VALUES FROM FILE
17430               DNAME$(J,I) = CNAME$(J,I)           ' SAVE COMPONENT NAME IN DUMMY FIELD
17431               DVALUE(J,I) = CVALUE(J,I)           ' SAVE COMPONENT VALUE IN DUMMY FIELD
17432           NEXT I                                  ' GET NEXT PAIR OF COMPONENTS
17433           GOTO 17438                              ' SKIP
17434           INPUT #1, TDUMMY(J)                     ' NUMBER OF COMPONENTS TO EXTRACT
17435           FOR I = 1 TO 30                         ' EXTRACT ALL DUMMY AIM ERROR COMPONENT NAMES AND VALUES
17436               INPUT #1, DNAME$(J,I), DVALUE(J,I)  ' EXTRACT COMPONET NAME AND VALUES FROM FILE
```

```
17437            NEXT I                                  ' GET NEXT PAIR OF DUMMY COMPONENTS
17438         NEXT J
17439         CLOSE 1
17440      RETURN
17441      '
17442      ' STORES COMPONENT ESTIMATES INTO FILE
17443      '
17800         IF GTYPE = 2 THEN OPEN "O",#1,"AEDAM.EST" : PK = 3
17810         IF GTYPE = 1 THEN OPEN "O",#1,"AEMDL.EST" : PK = 1
17811         FOR J = 1 TO PK
17812            IF J <> PM THEN GOTO 17852
17820            WRITE #1,TFACTOR(J)                  ' NUMBER OF COMPONENTS TO SAVED
17830            FOR I = 1 TO 30
17840               WRITE #1,CNAME$(J,I),CVALUE(J,I)  ' COMPONENT NAME AND VALUES SAVED
17850            NEXT I
17851            GOTO 17859
17852            WRITE #1,TDUMMY(J)                   ' NUMBER OF COMPONENTS TO SAVED
17854            FOR I = 1 TO 30
17857               WRITE #1,DNAME$(J,I),DVALUE(J,I)  ' COMPONENT NAME AND VALUES SAVED
17858            NEXT I
17859         NEXT J
17860         CLOSE 1
17870      RETURN
17900      '
17910      ' SPECIFY THEORETICAL CURVE FUNCTIONS
17920      '
17930         GOSUB 11650                                ' REFRESH SCREEN
17931         A$ = "\                                         \&\                 \"
17932         B$ = "\                                         \##.##\               \"
17933         C$ = "\                                        \####.##\              \"
17934         D$ = "\                                       \###.##\                \"
17935         E$ = "\                                 \&\             \"
17936         F$ = "\                                       \##.##\                 \"
17937         G$ = "\                                     \###.##\                  \"
17938         H$ = "\                                     \##.##\                   \"
17940         PRINT          "                 ____________________________________________"
17950         PRINT          "                |                                            |"
17960         PRINT          "                |       Define Battlefield Situation         |"
17965         PRINT USING A$;"                |          Projectile Type .....";RD$;" .....   1  |"
17966         PRINT USING B$;"                |          X Aim Point Adjustment ...";CJX;" m ....   2  |"
17967         PRINT USING B$;"                |          Y Aim Point Adjustment ...";CJY;" m ....   3  |"
17970         PRINT USING C$;"                |          Battlesight Range .....";RB;" m ....   4  |"
17980         PRINT USING D$;"                |          Crossdrift .....";VW;" m/s .....   5  |"
17990         PRINT USING E$;"                |          Target Type ...";TTYPE$;" .....   6  |"
18000         PRINT USING F$;"                |          Target Height .....";B;" m .....   7  |"
18010         PRINT USING G$;"                |          Target Speed ..... ";VR;" m/s .....   8  |"
18020         PRINT          "                |       Define Aim Error                     |"
18030         PRINT USING H$;"                |          Curve 1 .....";SIGMA1(1);" mils .....   9  |"
18040         PRINT USING H$;"                |          Curve 2 .....";SIGMA1(2);" mils .....  10  |"
18050         PRINT USING H$;"                |          Curve 3 .....";SIGMA1(3);" mils .....  11  |"
18052         PRINT          "                |       Store Curve Parameters .....  12  |"
18053         PRINT          "                |       Retrieve Curve Parameters .....  13  |"
18060         PRINT          "                |       Quit .....  14  |"
18070         PRINT          "                |____________________________________________|"
18080         PRINT " "
```

```
18090       INPUT "                                    Enter --) ";KM
18100       IF KM < 1 OR KM > 14 THEN GOTO 17930
18110       IF KM = 1 THEN GOSUB 730                    ' DEFINE PROJECTILE TYPE
18120       IF KM = 2 THEN GOSUB 8190                   ' DEFINE X AIM POINT ADJUSTMENTS
18125       IF KM = 3 THEN GOSUB 8270                   ' DEFINE Y AIM POINT ADJUSTMENTS
18130       IF KM = 4 THEN GOSUB 780                    ' DEFINE BATTLESIGHT RANGE
18140       IF KM = 5 THEN GOSUB 940                    ' DEFINE CROSSDRIFT
18150       IF KM = 6 THEN GOSUB 1090 GOSUB 1030        ' DEFINE TARGET TYPE
18160       IF KM = 7 THEN GOSUB 1250                   ' DEFINE TARGET HEIGHT
18170       IF KM = 8 THEN GOSUB 1540                   ' DEFINE TARGET SPEED
18190       IF KM = 9 THEN GORND = 0 : PM = 1 : GOSUB 15580 ' DEFINE AIM ERROR FOR CURVE 1
18200       IF KM = 10 THEN GORND = 0 : PM = 2 : GOSUB 15580 ' DEFINE AIM ERROR FOR CURVE 2
18210       IF KM = 11 THEN GORND = 0 : PM = 3 : GOSUB 15580 ' DEFINE AIM ERROR FOR CURVE 3
18212       IF KM = 12 THEN GOSUB 18850                 ' STORE BATTLEFIELD SITUATION
18213       IF KM = 13 THEN GOSUB 18710                 ' RETRIEVE BATTLFIELD SITUATION
18220       IF KM = 14 THEN GOTO 18240                  ' QUIT THEORETICAL CURVE DEFINITION MENU
18221       GOTO 17930                                  ' REDO THEORETICAL CURVE DEFINITION MENU
18222   '
18223   ' COMPUTE ALL THEORETICAL CURVE DATA POINTS AND PLOT CURVES
18224   '
18231       IF ADDTC = 0 THEN GOTO 18236
18232       GORND = 1
18233       FOR PM = 1 TO 3
18234           GOSUB 15580
18235       NEXT PM
18236       GOSUB 15190
18237       GORND = 0
18240   RETURN
18250   '
18260   ' DISPLAY EMPIRICAL DATA FUNCTION MENU
18270   '
18280       GOSUB 11650                          ' REFRESH SCREEN
18290       PRINT "                    ----------------------------------------"
18300       PRINT "                   |                                        |"
18310       PRINT "                   |    Define Empirical Data               |"
18320       PRINT "                   |        - Enter ..................  1 |"
18330       PRINT "                   |        - Retrieve ...............  2 |"
18360       PRINT "                   |    Store ........................  3 |"
18370       PRINT "                   |    Quit .........................  4 |"
18380       PRINT "                   |________________________________________|"
18390       PRINT " "
18400       INPUT "                                Enter --) ";KM
18410       IF KM < 1 OR KM > 4 THEN GOTO 18280
18420       IF KM = 1 THEN GOSUB 13590 : GOSUB 11800 : GOSUB 11990 : ECURVE$ = "  Defined  " ' ENTER EMPIRICAL DATA
18430       IF KM = 2 THEN GOSUB 13690 : GOSUB 11800 : GOSUB 11990 : ECURVE$ = "  Defined  " ' RETRIEVE ADDITION PLOT POINTS
18455       IF KM = 3 THEN GOSUB 12900                  ' SAVE ADDITIONAL PLOT POINTS
18470       IF KM = 4 THEN GOTO 18490                   ' RETURN TO THEORETICAL FUNCTION DATA
18480       GOTO 18280
18490   RETURN
18500   '
18510   ' DEVELOPMENT OF THEORETICAL HIT PROBABILITY CURVE DATA
18520   '
18560       TM = GM                                     ' SAVE ID IF CURVES TO BE PLOTED
18561       IF TGTNO <= 2 THEN GOSUB 10330              ' OUTPUT HIT PROBABILITY TABLE BY RANGE FOR E OR F SILOETTE TGT
18570       IF TGTNO > 2 THEN GOSUB 12910               ' OUTPUT HIT PROBABILITY BY RANGE FOR TANK TARGETS
```

```
18570       IF GM = 8 THEN GM = TM
18580       SNO = 1
18590       IF GM = 1 THEN PSTA = 1 : PEND = 1 : TCURVE$ = " Curve(s) 1 "          ' PLOT 1ST THEORETICAL CURVE
18600       IF GM = 2 THEN PSTA = 2 : PEND = 2 : TCURVE$ = " Curve(s) 2 "          ' PLOT 2ND THEORETICAL CURVE
18610       IF GM = 3 THEN PSTA = 3 : PEND = 3 : TCURVE$ = " Curve(s) 3 "          ' PLOT 3RD THEORETICAL CURVE
18620       IF GM = 4 THEN PSTA = 1 : PEND = 2 : TCURVE$ = " Curve(s) 1,2 "        ' PLOT 1ST & 2ND THEORETICAL CURVE
18630       IF GM = 5 THEN PSTA = 1 : PEND = 3 : SNO = 2 : TCURVE$ = " Curve(s) 1,3 " ' PLOT 1ST & 3RD THEORETICAL CURVE
18640       IF GM = 6 THEN PSTA = 2 : PEND = 3 : TCURVE$ = " Curve(s) 2,3 "        ' PLOT 2ND & 3RD THEORETICAL CURVE
18650       IF GM = 7 THEN PSTA = 1 : PEND = 3 : TCURVE$ = "Curve(s) 1,2,3"        ' PLOT ALL 3 THEORETICAL CURVES
18660    RETURN
18700    '
18701    ' RETRIEVE BATTLFIELD SITUATION DATA
18702    '
18710       OPEN "I",#1,"BATCOND.DAT"              ' OPENS FILE FOR DEFINED BATTLEFIELD SITUATION
18720       INPUT #1,RD$,PJ                        ' EXTRACT PROJECTILE TYPE & PROJECTILE ID CODE
18730       INPUT #1,CJX,CJY                       ' EXTRACT X & Y AIM POINT ADJUSTMENTS
18740       INPUT #1,RB                            ' EXTRACT BATTLESIGHT RANGE
18750       INPUT #1,VW                            ' EXTRACT CROSSDRIFT
18760       INPUT #1,TTYPE$,TGTNO                  ' EXTRACT TARGET TYPE & TARGET ID CODE
18770       INPUT #1,A,B,C,D,N                     ' EXTRACT TARGET DIMENSIONS
18780       INPUT #1,VR                            ' EXTRACT TARGET SPEED
18790       INPUT #1,SIGMA1(1),SIGMA1(2),SIGMA1(3) ' EXTRACT TOTAL AIM ERROR FOR EACH CURVE
18800       CLOSE 1
18810    RETURN
18820    '
18830    ' STORES BATTLEFIELD SITUATION DATA
18840    '
18850       OPEN "O",#1,"BATCOND.DAT"              ' OPENS FILE TO SAVE BATTLEFIELD SITUATION
18860       WRITE #1,RD$,PJ                        ' SAVE PROJECTILE TYPE & PROJECTILE ID CODE
18870       WRITE #1,CJX,CJY                       ' SAVE X & Y AIM POINT ADJUSTMENTS
18880       WRITE #1,RB                            ' SAVE BATTLESIGHT RANGE
18890       WRITE #1,VW                            ' SAVE CROSSDRIFT
18900       WRITE #1,TTYPE$,TGTNO                  ' SAVE TARGET TYPE & TARGET ID CODE
18910       WRITE #1,A,B,C,D,N                     ' SAVE TARGET DIMENSIONS
18920       WRITE #1,VR                            ' SAVE TARGET SPEED
18930       WRITE #1,SIGMA1(1),SIGMA1(2),SIGMA1(3) ' SAVE TOTAL AIM ERROR FOR EACH CURVE
18940       CLOSE 1
18950    RETURN
```

```
10        ' PURPOSE : TO OUTPUT X AND Y AXIS LABELS FOR 2 DIMENSIONAL GRAPH
20        SUB XYLABEL (N) STATIC
30            IF N = 1 THEN GOSUB 310 : GOSUB 170
40            IF N = 2 THEN GOSUB 630 : GOSUB 490
50            IF N = 3 THEN GOSUB 950 : GOSUB 810
60            IF N = 4 THEN GOSUB 1270 : GOSUB 1130
70            IF N = 5 THEN GOSUB 1590 : GOSUB 1450
80            IF N = 6 THEN GOSUB 1910 : GOSUB 1770
90            IF N = 7 THEN GOSUB 2230 : GOSUB 2090
100           IF N = 8 THEN GOSUB 2550 : GOSUB 2410
110           IF N = 9 THEN GOSUB 2860 : GOSUB 2720
120           IF N = 10 THEN GOSUB 3180 : GOSUB 3040
130           GOTO 3330
140       '
150       ' Y AXIS LABELS FOR 1 METER HIGH TARGET
160       '
170           LOCATE 6,4
180           PRINT "1"
190           LOCATE 9,3
200           PRINT ".5"
210           LOCATE 13,4
220           PRINT "0"
230           LOCATE 17,2
240           PRINT "-.5"
250           LOCATE 21,3
260           PRINT "-1"
270       RETURN
280       '
290       ' X AXIS LABELS FOR 1 METER HIGH TARGET
300       '
310           LOCATE 25,12
320           PRINT "-1.5"
330           LOCATE 25,23
340           PRINT "-1"
350           LOCATE 25,32
360           PRINT "-.5"
370           LOCATE 25,43
380           PRINT "0"
390           LOCATE 25,52
400           PRINT ".5"
410           LOCATE 25,61
420           PRINT "1"
430           LOCATE 25,70
440           PRINT "1.5"
450       RETURN
460       '
470       ' Y AXIS LABELS FOR 2 METER HIGH TARGETS
480       '
490           LOCATE 6,4
500           PRINT "2"
510           LOCATE 9,4
520           PRINT "1"
530           LOCATE 13,4
540           PRINT "0"
550           LOCATE 17,3
```

```
560             PRINT "-1"
570             LOCATE 21,3
580             PRINT "-2"
590         RETURN
600         '
610         ' X AXIS LABELS FOR 2 METER HIGH TARGETS
620         '
630             LOCATE 25,13
640             PRINT "-3"
650             LOCATE 25,23
660             PRINT "-2"
670             LOCATE 25,33
680             PRINT "-1"
690             LOCATE 25,43
700             PRINT "0"
710             LOCATE 25,52
720             PRINT "1"
730             LOCATE 25,61
740             PRINT "2"
750             LOCATE 25,70
760             PRINT "3"
770         RETURN
780         '
790         ' Y AXIS LABELS FOR 3 METER HIGH TARGET
800         '
810             LOCATE 6,4
820             PRINT "3"
830             LOCATE 9,2
840             PRINT "1.5"
850             LOCATE 13,4
860             PRINT "0"
870             LOCATE 17,1
880             PRINT "-1.5"
890             LOCATE 21,3
900             PRINT "-3"
910         RETURN
920         '
930         ' X AXIS LABELS FOR 3 METER HIGH TARGET
940         '
950             LOCATE 25,12
960             PRINT "-4.5"
970             LOCATE 25,23
980             PRINT "-3"
990             LOCATE 25,32
1000            PRINT "-1.5"
1010            LOCATE 25,43
1020            PRINT "0"
1030            LOCATE 25,51
1040            PRINT "1.5"
1050            LOCATE 25,61
1060            PRINT "3"
1070            LOCATE 25,69
1080            PRINT "4.5"
1090        RETURN
1100        '
```

```
1110        ' Y AXIS LABELS FOR 4 METER HIGH TARGET
1120        '
1130            LOCATE 6,4
1140            PRINT "4"
1150            LOCATE 9,4
1160            PRINT "2"
1170            LOCATE 13,4
1180            PRINT "0"
1190            LOCATE 21,3
1200            PRINT "-4"
1210            LOCATE 17,3
1220            PRINT "-2"
1230        RETURN
1240        '
1250        ' X AXIS LABELS FOR 4 METER HIGH TARGET
1260        '
1270            LOCATE 25, 14
1280            PRINT "-6"
1290            LOCATE 25, 23
1300            PRINT "-4"
1310            LOCATE 25, 32
1320            PRINT "-2"
1330            LOCATE 25, 43
1340            PRINT "0"
1350            LOCATE 25, 52
1360            PRINT "2"
1370            LOCATE 25, 61
1380            PRINT "4"
1390            LOCATE 25, 71
1400            PRINT "6"
1410        RETURN
1420        '
1430        ' Y AXIS LABELS FOR 5 METER HIGH TARGET
1440        '
1450            LOCATE 6,4
1460            PRINT "5"
1470            LOCATE 9,2
1480            PRINT "2.5"
1490            LOCATE 13,4
1500            PRINT "0"
1510            LOCATE 17,1
1520            PRINT "-2.5"
1530            LOCATE 21,3
1540            PRINT "-5"
1550        RETURN
1560        '
1570        ' X AXIS LABELS FOR 5 METER HIGH TARGET
1580        '
1590            LOCATE 25, 12
1600            PRINT "-7.5"
1610            LOCATE 25, 23
1620            PRINT "-5"
1630            LOCATE 25, 31
1640            PRINT "-2.5"
1650            LOCATE 25, 43
```

```
1660          PRINT "0"
1670          LOCATE 25,51
1680          PRINT "2.5"
1690          LOCATE 25,61
1700          PRINT "5"
1710          LOCATE 25,70
1720          PRINT "7.5"
1730      RETURN
1740      '
1750      ' Y AXIS LABELS FOR 6 METER HIGH TARGET
1760      '
1770          LOCATE 5,4
1780          PRINT "6"
1790          LOCATE 9,4
1800          PRINT "3"
1810          LOCATE 13,4
1820          PRINT "0"
1830          LOCATE 17,3
1840          PRINT "-3"
1850          LOCATE 21,3
1860          PRINT "-6"
1870      RETURN
1880      '
1890      ' X AXIS LABELS FOR 6 METER HIGH TARGET
1900      '
1910          LOCATE 25,14
1920          PRINT "-9"
1930          LOCATE 25,23
1940          PRINT "-6"
1950          LOCATE 25,32
1960          PRINT "-3"
1970          LOCATE 25,43
1980          PRINT "0"
1990          LOCATE 25,52
2000          PRINT "3"
2010          LOCATE 25,61
2020          PRINT "6"
2030          LOCATE 25,71
2040          PRINT "9"
2050      RETURN
2060      '
2070      ' Y AXIS LABELS FOR 7 METER HIGH TARGET
2080      '
2090          LOCATE 5,4
2100          PRINT "7"
2110          LOCATE 9,2
2120          PRINT "3.5"
2130          LOCATE 13,4
2140          PRINT "0"
2150          LOCATE 17,1
2160          PRINT "-3.5"
2170          LOCATE 21,3
2180          PRINT "-7"
2190      RETURN
2200      '
```

```
2210        ' X AXIS LABELS FOR 7 METER HIGH TARGET
2220        '
2230            LOCATE 25,12
2240            PRINT "-10.5"
2250            LOCATE 25,23
2260            PRINT "-7"
2270            LOCATE 25,31
2280            PRINT "-3.5"
2290            LOCATE 25,43
2300            PRINT "0"
2310            LOCATE 25,51
2320            PRINT "3.5"
2330            LOCATE 25,61
2340            PRINT "7"
2350            LOCATE 25,70
2360            PRINT "10.5"
2370        RETURN
2380        '
2390        ' Y AXIS LABELS FOR 8 METER HIGH TARGETS
2400        '
2410            LOCATE 6,4
2420            PRINT "8"
2430            LOCATE 9,4
2440            PRINT "4"
2450            LOCATE 13,4
2460            PRINT "0"
2470            LOCATE 17,3
2480            PRINT "-4"
2490            LOCATE 21,3
2500            PRINT "-8"
2510        RETURN
2520        '
2530        ' X AXIS LABELS FOR 8 METER HIGH TARGETS
2540        '
2550            LOCATE 25,13
2560            PRINT "-12"
2570            LOCATE 25,23
2580            PRINT "-6"
2590            LOCATE 25,32
2600            PRINT "-4"
2610            PRINT "0"
2620            LOCATE 25,52
2630            PRINT "4"
2640            LOCATE 25,61
2650            PRINT "8"
2660            LOCATE 25,70
2670            PRINT "12"
2680        RETURN
2690        '
2700        ' Y AXIS LABELS FOR 9 METER HIGH TARGETS
2710        '
2720            LOCATE 6,4
2730            PRINT "9"
2740            LOCATE 9,2
2750            PRINT "4.5"
```

```
2760          LOCATE 13,4
2770          PRINT "0"
2780          LOCATE 17,1
2790          PRINT "-4.5"
2800          LOCATE 21,3
2810          PRINT "-9"
2820      RETURN
2830      '
2840      ' X AXIS LABELS FOR 9 METER HIGH TARGETS
2850      '
2860          LOCATE 25,12
2870          PRINT "-13.5"
2880          LOCATE 25,23
2890          PRINT "-9"
2900          LOCATE 25,31
2910          PRINT "-4.5"
2920          LOCATE 25,43
2930          PRINT "0"
2940          LOCATE 25,51
2950          PRINT "4.5"
2960          LOCATE 25,61
2970          PRINT "9"
2980          LOCATE 25,69
2990          PRINT "13.5"
3000      RETURN
3010      '
3020      ' Y AXIS LABELS FOR 10 METER HIGH TARGET
3030      '
3040          LOCATE 6,3
3050          PRINT "10"
3060          LOCATE 9,4
3070          PRINT "5"
3080          LOCATE 13,4
3090          PRINT "0"
3100          LOCATE 17,3
3110          PRINT "-5"
3120          LOCATE 21,2
3130          PRINT "-10"
3140      RETURN
3150      '
3160      ' X AXIS LABELS FOR 10 METER HIGH TARGET
3170      '
3180          LOCATE 25,13
3190          PRINT "-15"
3200          LOCATE 25,22
3210          PRINT "-10"
3220          LOCATE 25,32
3230          PRINT "-5"
3240          LOCATE 25,43
3250          PRINT "0"
3260          LOCATE 25,52
3270          PRINT "5"
3280          LOCATE 25,61
3290          PRINT "10"
3300          LOCATE 25,70
```

```
3310          PRINT "15"
3320       RETURN
3330       END SUB
```

APPENDIX C

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM FILE LISTING

MARKSMANSHIP AIMING AND TRACKING ANALYSIS SYSTEM FIELD LISTING

Appendix C lists and describes the system data and batch files required to run MATAS.

Data Files:

"POINTS.SIL" - contains empirical data points for both E- and F-silhouette targets. These data points are based on user-defined target range and associated hit probability for the graphic analysis module.

"POINTS.TNK" - contains empirical data points for both Tank - front and side view targets. These data points are based on user-defined target range and associated hit probability for the graphic analysis module.

"AEMDL.EST" - contains as many as 30 aim error component estimates. These estimates are based on user-defined estimates (component name and associated value) which form the composite aim error values in the parameter analysis module.

"AEDAM.EST" - contains as many as 30 aim error component estimates. These estimates are based on analyst-defined aim error values. These values are used to generate the hit probability curves in the graphic analysis module.

"BATCOND.DAT" - contains the battlefield situation and the total aim error for each theoretical curve defined in the graphic analysis module.

Batch Files:

"AUTOEXEC.BAT" - executes "GRAPHICS" which runs in RAM and allows the user the capability to print screen displays if the IBM graphics printer is available and the model itself "AESMAX6."

"INSTALL.BAT" - installs the MATAS to the hard disc by creating a directory and copying all required files into that directory.

"MATAS.BAT" - executes "GRAPHICS" and "AESMAX6" the model.